AD NUMBER
AD801306
CLASSIFICATION CHANGES
TO: unclassified
FROM: secret
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; JUL 1952. Other requests shall be referred to Defense Nuclear Agency, Washington DC.
AUTHORITY
DNA ltr, 10 Aug 1984; DNA ltr, 10 Aug 1984

AD 801306

AUTHORITY: DNA ltr, 10 Aug 84

~~SECRET~~

UNCLASSIFIED

(18) AEC

(19) WT-407

This report consists of 114 plus 4 pages (counting preliminary pages)

No. 360 of 373 copies, Series A

AD 801 306

(21) Report on
OPERATION BUSTER,

PROJECT 2.4b.

(6) THERMAL RADIATION EFFECTS ON PAINTS
PLASTICS AND COATED FABRICS,

(9) Rept. for Oct - Nov 51,

~~by~~

(10) HARVEY MILLER

(11) Jul[redacted]52

(12) 104p.

BEST AVAILABLE COPY

ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES

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038 050

~~SECRET~~
~~Security Information~~

UNCLASSIFIED

~~RESTRICTED DATA~~
~~ATOMIC ENERGY ACT 1946~~

ecb

ACKNOWLEDGEMENTS

This report was prepared under the administrative supervision of Mr. Arthur W. Van Heuckeroth. The author acknowledges the encouragement and assistance of Mr. George W. Howard and Mr. Neil Dickenson who offered valuable assistance in the planning and preparation of this project. Much credit is due to Capt. W. G. Kratz, and the other members of the Special Projects Branch, for help in the actual accomplishment of the work both at ERDL and at the test site. Credit is also extended to NRDL and NML for data and other information used in this report.

The testing and evaluation of the plastic samples returned to ERDL as well as the preparation of these samples was done by Mr. George Farmer, and the work on the coated fabrics by Mr. Clifford M. Brown. The assistance of Mr. J. D. Chapman in testing and evaluating the paint samples returned to ERDL is also appreciated.

CONTENTS

ACKNOWLEDGEMENTS iii

ABSTRACT. ix

CHAPTER 1 INTRODUCTION. 1

1.1 Objectives. 1
1.2 Historical. 1
1.3 Theoretical Considerations 2

CHAPTER 2 EXPERIMENTAL. 4

2.1 Preparation of Samples for Laboratory Evaluation at NML 4
2.2 Preparation of Samples for Field Exposure 4
2.3 Construction of Test Racks 4
2.4 Experimental Plan for Field Exposures. 5
2.5 ERDL Evaluation of Exposed Panels . . 6

CHAPTER 3 RESULTS OF DIFFERENT EXPOSURES 7

3.1 NML Laboratory Exposure Tests . . . 7
3.2 Field Observations 7
3.3 ERDL Laboratory Evaluation Tests . . 10

CHAPTER 4 DISCUSSION OF RESULTS. 12

4.1 NML Exposure Results 12
4.2 Field Exposure Results. 13
4.3 ERDL Evaluation 15
4.4 Comparison of Laboratory Flux and Field Exposure Tests 21

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS 23

5.1 Conclusions. 23
5.2 Recommendations 24

BIBLIOGRAPHY 26

APPENDIX A 27

A.1 Preparation of Samples for NML Laboratory Tests 27
A.2 Preparation of Samples for Field Exposure Tests 32
A.3 Construction of Racks for Field Tests . 35

APPENDIX B 38

B.1 Method of Evaluating Damage to Samples NML 38
B.2 ERDL Laboratory Evaluation Tests . . 39
B.3 Method of Evaluating Damage to Samples ERDL. 41

APPENDIX C 43

Laboratory and Field Test Data 43

ILLUSTRATIONS

CHAPTER 2 EXPERIMENTAL

2.1 Typical Group of Panels prepared for NML Laboratory Exposure 5

CHAPTER 3 RESULTS OF DIFFERENT EXPOSURES

3.1 Paint systems after Field Exposure at Different Intensity Levels. 8
3.2 Plastics and Coated Fabrics Samples After Exposure at Different Intensity Levels 9

CHAPTER 4 DISCUSSION OF RESULTS

4.1 Typical Group of Panels After Exposure to Thermal Flux at NML. 14
4.2 Effect of Thermal Flux on Outside White Paint and a Fire Retardant Paint. . . . 18
4.3 Fire Retardancy Test After Exposure to Thermal Flux 19

APPENDIX A

A.1 Construction of the Racks Used For Field Exposure 36

APPENDIX C

C.1 The Effect of Thermal Flux on an Alkyd Lusterless Enamel.
C.2 The Effect of Thermal Flux on Certain Fibers.
C.3 The Effect of Thermal Flux on Certain Coated Fabrics.

TABLES

APPENDIX A

A.1 Coding of Paint Samples Prepared for NML Testing
A.2 Coding of Plastics, Coated Fabrics and Packaging Materials for NML Testing
A.3 Coding of Paint Samples for Field Exposure
A.4 Coding of Plastic and Coated Fabrics Samples for Field Exposure

APPENDIX C

C.1 Results of Exposure to Laboratory Thermal Flux on Certain Materials
C.2 Thermal and Blast Data (Field Exposures)
C.3 Thermal Exposure Effects, BAKER Shot
C.4 Thermal Exposure Effects, DOG Shot 2000 ft.
C.5 Thermal Exposure Effects, DOG Shot
C.6 Effect of Thermal Flux on Resistance to Salt Spray.
C.7 Effect of Thermal Flux on Resistance to Accelerated Weathering
C.8 Effect of Thermal Flux on Resistance to High Humidity
C.9 Effect of High Humidity on Painted Panels Exposed to a Thermal Energy of 85 cal/cm^2
C.10 Effect of Thermal Flux on Overall Flexibility
C.11 Effect of Thermal Flux on Overall Abrasion Resistance

C.12 Effect of Thermal Flux on Overall Shear Hardness
C.13 Effect of Thermal Flux on the properties of Fire Retardant Paint
C.14 Effect of Thermal Flux on Rigid Plastics
C.15 Effect of Thermal Flux on Plastic Films
C.16 Effect of Thermal Flux on Plastic and Cotton Fibers
C.17 Effect of Thermal Flux on the Breaking Strength of Rubber Coated Fabrics
C.18 Effect of Thermal Flux on the Elongation of Coated Fabrics
C.19 Comparison of the Thermal Effects of Laboratory Flux vs Field Exposure

ABSTRACT

The object of this project was to determine the effect of thermal flux and other atomic blast phenomena on the service life and use characteristics of selected paint systems, plastics and coated fabrics currently used or proposed for use by the Corpe of Engineers. Little or no work has been done previously on evaluating the effect of atom weapon phenomina on these properties. Selected materials were exposed to a laboratory source of thermal flux using Navy searchlight method, with the object of establishing a correlation between laboratory and field test results. Representative paint systems, plastics and coated fabrics were exposed to BAKER and DOG shots at thermal energies ranging from 1.6 cal./cm² to 85 cal./cm². The samples were given a visual inspection in the field and returned to ERDL for laboratory comparison with samples retained at ERDL, to determine the effect of the exposures on the physical properties of the materials.

39 cm The main conclusions were: 39 cm

1. That visual inspection does not always give a true picture and that subsequent laboratory testing of the exposed samples is necessary for accurate, effective evaluation of the damage done and the condition of the material.

2. That certain paint systems showed different degrees of damage when painted on different kinds of metal surfaces, and that the effect of the kind of metal surface on the damage to one coating system cannot be used to predict its effect on other coating systems.

3. That paint systems applied to metal surfaces although completely destroyed by high intensities of thermal flux will impart improved rust and corrosion resistance to these surfaces even under high humidity conditions.

4. Wood panels coated with a developed fire retardant paint showed a critical energy for wood charring of seven times that of the unpainted wood and twice that of ordinary house paint.

5. That the fire retardant paint even though completely destroyed by high thermal intensity and blast damage gave the underlying wood good protection against burning that was not found in the other paint systems.

6. That the rigid plastics showed little damage below 18 cal./cm^2 while most of the plastic films and fibers had a critical energy in a range of from 10 to 18 cal./cm^2.

7. Subsequent laboratory tests show that the damage to coated fabrics at intensities up to 10 cal./cm^2 is a surface effect that does not affect the fabric itself, but that intensities of 18 cal./cm^2 will severely damage the fabric.

8. Comparison of laboratory thermal data (searchlight source) with field results shows only fair correlation. Occasional contradiction is evidenced.

It is recommended that:

1. Critical wood structures subject to atomic blast exposure, be coated with an adequate fire retardant paint.

2. Epoxy resin type finishes be considered for use on metal equipment subject to these conditions.

3. That the polyester-fiberglas type of plastic be used where there is a need for a rigid type plastic with a high resistance to thermal flux.

4. That coated fabrics be flame-proofed before coating.

5. That additional data (for use in formulating better coatings and materials for specific military requirements) be obtained on:

a. The damage done to the different coatings when painted on magnesium surfaces. This is important due to the increasing use of magnesium in the construction of airborne equipment.

b. The effect of these phenomena on fire retardant paint formulated to an O.D. or camouflage color.

c. The damage to plastic film and fibers in the critical range of 10 to 18 cal./cm^2.

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVES

In the Engineer Research and Development Laboratories thermal project, conducted in conjunction with operation BUSTER, certain specific paint systems, plastics and coated fabrics, currently used, or proposed for use, by the Corps of Engineers, were exposed to the thermal effects and accompanying phenomena of an atom bomb blast. This was done in order to study and evaluate, by scientific tests, the effect of these exposures on the expected service life of the different paint systems, plastics and coated fabrics and the ability of the coating systems to protect the underlying surfaces from the thermal and sandblast effects of the explosion. It is important to know to what degree these coatings will continue to protect the equipment from normal weathering conditions after exposure to these phenomena. This will determine the necessity and/or desirability of removing the exposed material and replacing it with new material. It will also indicate any need for better, more resistant coatings or materials.

1.2 HISTORICAL

The total energy in cal/cm^2 and delivery time, as well as intensities in cal/cm^2/sec delivered at various distances are the quantities on which thermal effects depend. Such a small number of measurements have been made thus far, as evidenced by the reports on SANDSTONE and GREENHOUSE, that only general conclusions and predictions can be drawn from previous tests.

A large amount of work by various members of the protective coatings industry has been done on the evaluation of the different paint systems, plastics and coated fabrics for ordinary usage. Mattiello[1] gives a very good discussion of the various laboratory tests and their correlation with field tests results. F. F. LaQue[2] of the International Nickel Company is doing extensive work on the corrosion of metals and metal protective systems. Considerable work has been done by Miller[3] at ERDL in the development of fire retardant paints and paint systems. Isano oil was found to be effective in one formulation. A study of literature, however, fails to reveal significant information on the

effect of thermal flux or other atomic weapon phenomena on these materials. No evaluation of the effects of these phenomena on the service life or use characteristics was found. When operation BUSTER was proposed, it was suggested by the Office, Chief of Engineers that a project be set up to secure information on these thermal effects. The answers to the following questions were desired:

(a) What is the expected service life of these coatings and other materials after exposure to the effects?

(b) To what degree are their protective properties and/or use characteristics impaired?

(c) In what specific characteristics do the materials fail?

(d) Can an improved coating or other material be developed that will overcome these failings?

(e) Will the coating give adequate protection to the underlying surface under forseeable conditions?

Work has been done by other laboratories in this and previous operations in exposing various materials to atomic phenomena and studying these effects, but little has been done in evaluating the effect of these phenomena on the service life of paint systems and other materials used specifically by the Corps of Engineers.

1.3 THEORETICAL CONSIDERATIONS

An important difference between an atomic and a conventional explosion is that the energy liberated per unit mass is much greater and the temperature attained is much higher in the former case, with the result that a larger proportion of the energy is liberated as thermal radiations.

The characteristics of the thermal radiations from an atomic explosion as derived from theoretical considerations are discussed in some detail in the "Effects of Atomic Weapons[4]. According to theory, approximately one third of the total energy released is emitted as thermal radiation. At about 0.1 millisecond after the detonation, the fire ball consists of an isothermal sphere of about 50 feet radius and having a temperature of about 300,000 ° K. From theoretical considerations, it may be assumed that the fire ball emits essentially black-body radiation.

Before the characteristics of the thermal energy received at any distance from the fire ball can be estimated, it is necessary to correct for atmospheric attenuation both by the undisturbed atmosphere present at a distance from point zero, and by the abnormal atmosphere produced around point zero by the detonation itself. At the present time, it must be said that sufficient uncertainties still exist on theoretical grounds, to render of limited value, quantitative calculations of the characteristics of thermal energy received at any distance from point zero. Physical measurements in actual field operations are needed to correlate and check the theoretical calculations. These measurements are made with calorimeters and passive indicators. The calorimeters measure the total integrated energy while passive indicators, such as certain textiles, plastics and other materials, measure only the effective flux, that is, the flux that will initiate and sustain damage.

The intense ultraviolet radiations emitted in the first millisecond of the detonation is only a small fraction of the total energy released and will not in itself produce visible damage; however, it may set up photochemical or other reactions that could affect the service life of the materials. To evaluate this condition and the other thermal effects, as well as the other phenomena, identical unexposed panels were concurrently evaluated at ERDL. This service evaluation of identical exposed and unexposed samples show the differences which are attributable to the effect of atomic weapon phenomena.

CHAPTER 2

EXPERIMENTAL

2.1 NAVAL MATERIALS LABORATORY EVALUATION TESTS

A series of paint systems, plastics, coated fabrics, and packaging materials were prepared for exposure to the NML laboratory source of thermal flux.

Tables A.1 and A.2, Appendix A, lists the samples submitted. A description of the method of preparation of these samples is also included. These samples were subjected to exposure to thermal flux by the laboratory searchlight method as described in NML BUSTER report No. WT311. In this method the beam of a 24 inch Navy searchlight is directed to a receiving mirror which concentrates the energy at a focal point. The sample is made to pass through this focal point at a constant acceleration or deceleration, with the total energy and time of exposure determining the amount of thermal flux at any point. The energy level is determined by placing calibration strips along the side of the sample and converting the speed of travel into thermal energy in calories per square centimeter. Photograph 2.1 shows typical samples prepared for this exposure.

2.2 PREPARATION OF SAMPLES FOR FIELD EXPOSURE

Selected paint systems including alkyds, phenolics, epons, vinyls and a recently developed fire retardant paint, were applied to steel, aluminum and wood surfaces. Representative samples of plastics and coated fabrics were also included. Tables A.3 and A.4 listing these materials as well as a description of the method of preparation are included in Appendix A.

2.3 CONSTRUCTION OF TEST RACKS

The test racks were designed and built, at ERDL, for these tests. They are inexpensive, light, but sturdy racks anchored by steel stakes and require only 6 to 8 man hours to erect in the field. The racks have detachable panel sections that assure quick easy removal of the samples to an uncontaminated area where they may be examined at leisure. A photograph and detailed description of the rack are contained in Appendix A.

Fig. 2.1 Typical Group Of Panels Prepared For NML Laboratory Exposure

2.4 EXPERIMENTAL PLAN FOR FIELD EXPOSURES

A series of paint systems, plastics and coated fabrics were prepared as described in paragraph 2.2 for exposure at four stations for both Baker and Dog Shots, with an extra rack for Dog Shot. The test panels were attached to the rack sections in the camp laboratories where they were sheltered from the weather until the afternoon before the shot. The racks were set up at the various stations, adjacent to the Thermal Line and on a radius from ground zero, with the face of the rack oriented to receive maximum thermal energy. The stations were located at the following distances from expected ground zero.

2.4.1 Baker Shot

Station 1 - 2000 feet
Station 2 - 4000 feet
Station 3 - 5000 feet
Station 4 - 7000 feet

2.4.2 Dog Shot

Station 1 - 5000 feet
Station 2 - 7000 feet
Station 3 - 9000 feet
Station 4 - 12000 feet
Station 5 - 2000 feet
(1 rack of paint panels)

After each exposure, the test panels were monitored for possible contamination and given a visual inspection for damage, then returned to the camp laboratory for a more careful inspection. To acquire information on the structural behavior of these light racks, a rack with the face completely covered by two 3' x 5' plywood panels was set at 9000 feet on DOG Shot with the stakes just driven into the ground.

2.5 ERDL EVALUATION OF EXPOSED PANELS

The sample panels exposed in 2.4 were returned to ERDL for laboratory evaluation with duplicate panels retained at the laboratories. The paint samples were subjected to salt spray, accelerated weathering and high humidity and then evaluated for flexibility, abrasion resistance and shear hardness. Any differences between the two sets of panels was attributed to the field exposure. The panels coated with fire retardant and ordinary house paint were given standard conditioning, and evaluated for fire retardant properties as specified in Federal Specification TT-P-26.

The plastics and coated fabrics were evaluated for damage, by the usual laboratory tests of flexual and breaking strength, elongation, surface hardness, and light transmission. A detailed description of the test procedures are given in Appendix B.

CHAPTER 3

RESULTS OF DIFFERENT EXPOSURES

3.1 RESULTS OF NML LABORATORY EXPOSURE TESTS

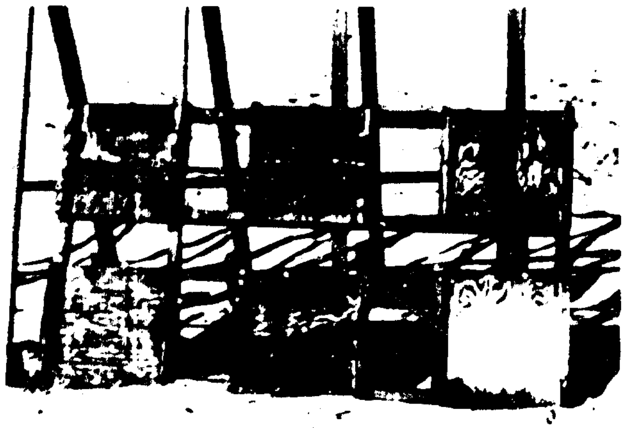
The results of this exposure test are shown in Table C.1, "The Effect of Exposure to Laboratory Thermal Flux on Certain Materials."

3.2 FIELD EXPOSURE TESTS

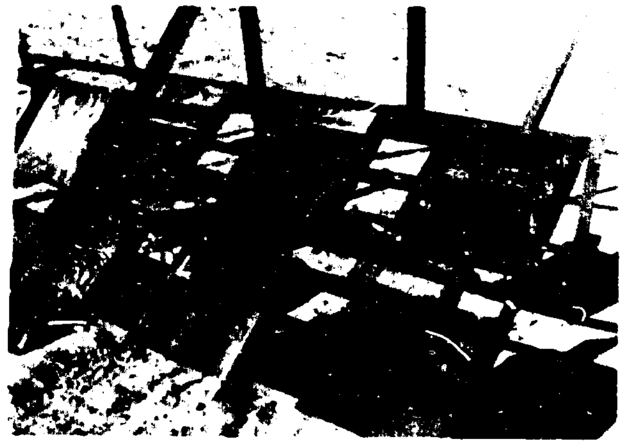
Samples of paints, plastics, and coated fabrics were exposed to the BAKER and DOG Shots, at four different stations, yielding intensity levels varying from 1.6 to 85 cal/cm^2. Figures 3.1 and 3.2 show typical damage to these materials at selected intensity levels. It should be noted that this damage is caused by both thermal and blast effects. Considerable thought was given to methods of distinguishing between thermal and blast damage. The use of quartz windows or electronically operated shutters were not considered practical because of the number and size of the samples to be exposed made their use excessive in cost. While this was primarily a thermal effects project, the Engineers were also interested in the actual damage, (thermal and blast), to the materials. In every case possible, the blast damage has been allowed for in the evaluation of the thermal damage to the sample. Table C.2, showing the thermal flux and blast pressures, as well as Tables C.3, C.4, and C.5, giving the results of the field exposure, are included in Appendix C. A selective summary of these data follows:

At 85 calories all of the paint systems were completely destroyed. The panels with the epoxy type finish appeared to have small bits of paint left on the surface, while the panels with the vinyl type finish had a greyish mat finish. The panels coated with house paint and with fire retardant paint showed complete destruction of the paint film and excessive sand erosion. No plastics or coated fabrics were exposed at this station.

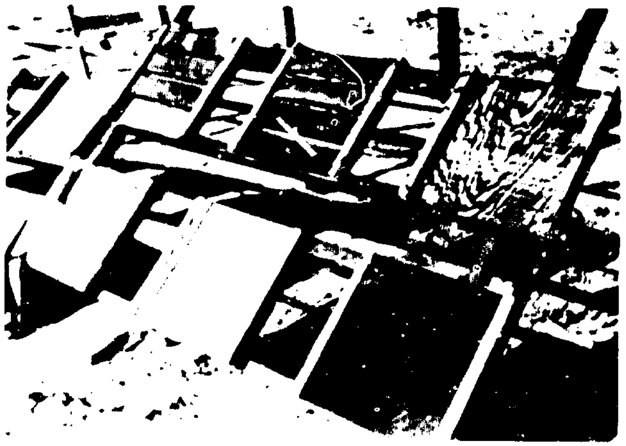
At 18 calories most of the paint systems showed charring and blistering. The coated pine panels showed blistering with a red color in the rosin grain. The coated poplar panels showed charring but no blistering. The rigid plastics showed little damage, while the plastic films and fibers were destroyed. Some of the coated fabrics were completely destroyed, others were melted and charred.



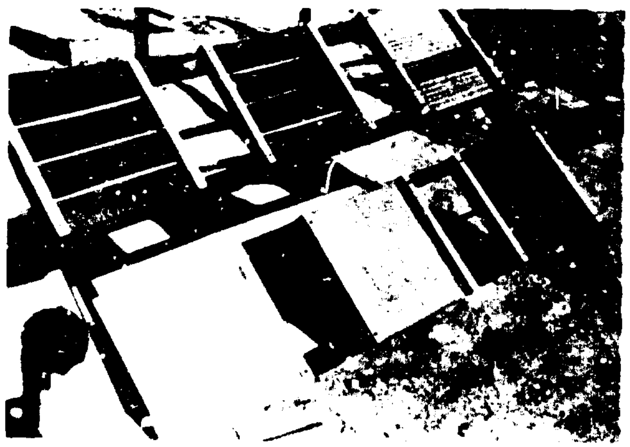
17.5 cal/cm^2



18.5 cal/cm^2

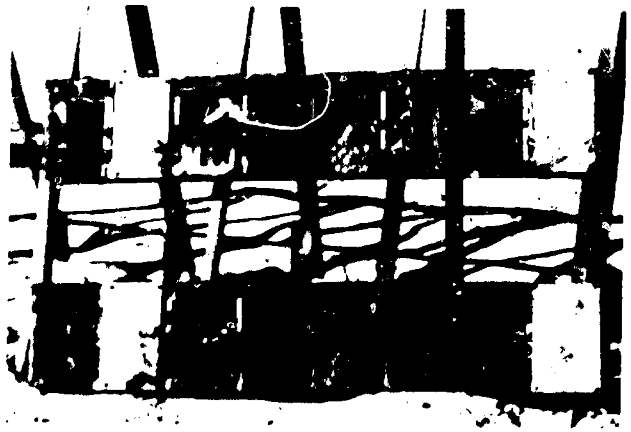


9.6 cal/cm^2

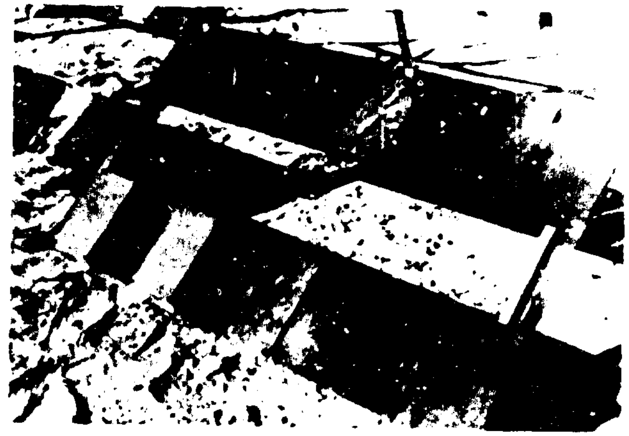


1.6 cal/cm^2

Fig. 3.1 Paint Samples After Field Exposure at Different Intensity Levels



17.5 cal/cm²



18.5 cal/cm²

9.6 cal/cm²

1.6 cal/cm²

Fig. 3.2 Plastic Samples After Field Exposure at Different Intensity Levels

At 9.8 cal/cm^2 the paint systems on metal panels showed some gravel damage with the aluminum panels showing a few blisters. The coatings on pine wood panels showed blistering and charring. The poplar panels coated with house paint showed some blistering while the fire retardant paint showed none. The rigid plastic films and fibers, and the coated fabrics did show some damage.

At energies below 5.7 cal/cm^2 the paints on metal panels showed occasional fine blisters with the aluminum panels showing slightly more damage than the steel. The pine panels showed blistering and some light charring. The vinyl and saran films and the saran fiber showed some damage. Some of the coated fabrics showed some surface damage.

3.3 ERDL EVALUATION TESTS

3.3.1 Evaluation of Paint Systems on Metals

The alkyd, phenolic, vinyl and epoxy systems coated on steel and aluminum were exposed to salt spray, accelerated weather and high humidity and then evaluated for flexibility, abrasion resistance and shear hardness. The results of these evaluations are included in Appendix C in the following tables.

Table C.6	Effect of Thermal Flux on Resistance to Salt Spray Exposure
Table C.7	Effect of Thermal Flux on Resistance to Accelerated Weathering Exposure
Table C.8	Effect of Thermal Flux on Resistance to High Humidity
Table C.9	Effect of High Humidity on Painted Panels Exposed to a Thermal Energy of 85 cal/cm^2
Table C.10	Effect of Thermal Flux on Flexibility
Table C.11	Effect of Thermal Flux on Abrasion Resistance
Table C.12	Effect of Thermal Flux on Shear Hardness

3.3.2 EVALUATION OF FIRE RETARDANT PAINTS

Test panels of outside white paint and fire retardant paint were evaluated for fire retardancy under Fed. Spec. TT-P-26.

Table C.13, Appendix C, shows the effect of thermal flux on the fire retardant properties of these two paints.

3.3.3 Evaluation of Plastics and Coated Fabrics

The rigid plastics, plastic films and fibers and coated fabrics were evaluated for the effect of thermal flux on their physical properties. The results of these evaluations are shown in the following tables in Appendix C.

Table C.14	Effect of Thermal Flux on Rigid Plastics
Table C.15	Effect of Thermal Flux on Plastic Films
Table C.16	Effect of Thermal Flux on Plastic and Cotton Fibers
Table C.17	Effect of Thermal Flux on the Breaking Strength of Coated Fabrics
Table C.18	Effect of Thermal Flux on the Ultimate Elongation of Coated Fabrics

3.3.4 Comparison of Laboratory Flux and Field Exposure

Field exposure results on fourteen paint systems were compared with the results obtained from exposure to laboratory flux on the same systems The results of this comparison are shown in Table C.19, Appendix C.

CHAPTER 4

DISCUSSION OF RESULTS

4.1 NML EXPOSURE TESTS

An examination of Table C.1, Appendix C, will show the effect of these exposures. An examination of these results will show that the alkyd and phenolic paint systems had a higher critical energy when coated on aluminum than on steel or magnesium, while the critical energy of the epoxy resin system was higher on steel and magnesium than it was on aluminum. In the case of the alkyd and phenolic systems, this might be accounted for by the different heat conductance of the different metals. The results of the epoxy resin system, however, show that this reasoning cannot be applied indiscriminately in predicting the damage to other paint systems on these metals.

It can also be seen from these results that a good fire retardant paint should have a critical energy that is eight times that of unpainted wood and twice that of ordinary paint.

The values reported for the fibers do not reflect the true damage from thermal flux. It was noted, from close inspection, that damage to the fibers was caused more by the ignition of the wood than by thermal radiation falling on the fiber itself.

The rigid plastics were run at high calorie ranges. The early charring of the wood in some cases, was accounted for by the transparency of such samples as cellulose acetate and acrylic resin (plexiglass). The cellulose acetate showed marked effect from the incident radiation i.e. melting, as well as from the burning of the plywood backing. The acrylic resin however, was destroyed totally by the plywood backing, complicating the evaluation. The polyester-fiberglass material offered good protection to the underlying wood even though the specimens were run to a high range (427 to 853 cal/cm^2). At low intensities the thickness of the coated fabrics acted as a thermal barrier protecting the underlying surface. It is seen from this table that the nitrile rubber coated fabric had the highest critical energy while the neoprene and styrene rubbers had the lowest.

Difficulty was experienced in the evaluation of some of the packaging materials. The surface, both front and back of several

of the materials were stencilled in black print and the black print absorbed more of the energy than the adjacent areas. Some of the materials stuck to each other or to the wrapping paper altering the surface appearance of the material. Typical damage caused by this exposure is shown in Figure 4.1.

4.2 FIELD EXPOSURE TESTS

A study of the samples at the various stations for both shots reveals a reasonably good correlation between the energy received and the amount of damage. It is also signficant to note that there was no radioactive contamination found on any of the samples even though the surrounding areas did show some contamination. This is possibly due to the fact that the samples were in a nearly vertical position and thus missed any fall out of radioactive particles.

As would be expected, all of the paint systems were destroyed at the 85 cal/cm^2 level. One paint, the epoxy resin system, appeared to have small flecks of the paint left on the panel. This raises the question "were the paints burnt off by thermal effects or was the damage caused by the blast effects"? This could be determined at a future test using shielded and unshielded samples.

It was also significant to note that the poplar panels coated with fire retardant paint and ordinary house paint had the paint completely destroyed and the panels deeply sandblasted. A visual evaluation shows the two panels to be identical.

At the 18 calorie station it was noted that the alkyd luster-less enamel showed better resistance, when coated on steel, that it did on aluminum. It was thought that this could be accounted for by the higher specific conductivity of steel over aluminum, however, the phenolic system showed the reverse effects with the phenolic system showing less damage over the aluminum. It was seen that the pine panels were covered with red blisters grading to black in the charred areas. This red coloration is probably due to the rosin content of the wood or a combination of the rosin and some constituent of the paint. This reasoning is further borne out by the fact that the poplar panels showed no blistering or red color. It would seem from these results that it would be desirable to have all critical buildings constructed of non-resinous wood or to determine whether the fire retardant paint would eliminate the blistering of the pine wood. A further study of this data reveals that the exterior fire retardant paint shows less deterioration and gives better protection than the outside white paint.

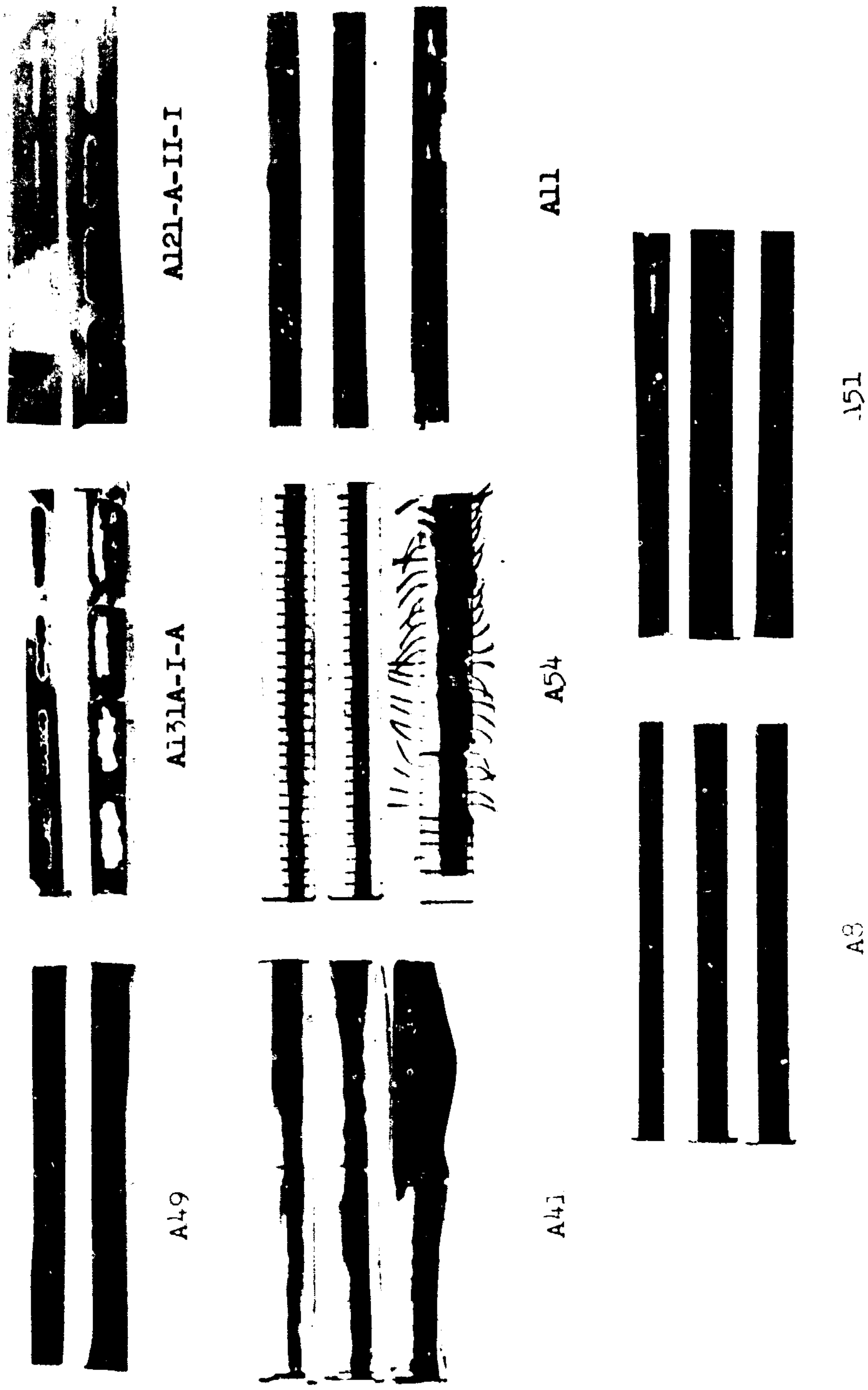


Fig. 4.1 Typical Group Of Panels After Exposure To Thermal Flux At NML

An evaluation of the plastics and coated fabrics reveal that the rigid type plastics show very little damage, the phenol-formaldehyde and the polyvinyl chloride samples show a little heat scorching. The absence of the blast damage is probably due to the thickness of the sample. The plastic films and fibers were completely gone with the exception of the vinyl covered glass fiber, in which case, the glass fibers remained. It is difficult to determine whether this damage was caused by thermal or blast effects. The coated fabrics showed surface melting, charring, and the imbedding of a layer of sand and fine gravel. The untreated duck sample and the material coated with a laboratory batch of neoprene rubber were completely destroyed, but again it is impossible to say to which effect this was due. Again, at the 9.6 cal station we find the alkyd system showing slightly less damage on steel than it does on aluminum. The phenolic system fails to show any differentiation at this level. It is to be noted that the house paint is blistered at intensities of this level while the fire retardant paint shows no damage. It is also noted that the plastic films, fibers, and the coated fabrics continue to show no damage. It is also noted that the plastic films, fibers, and the coated fabrics continue to show some damage. It is noted that some of the plastic materials particularly saran and vinyl films were completely destroyed at intensities of 5.6 cal/cm^2 and below. This is probably due to thermal flux rather than blast damage since NML laboratory results show these materials to have low critical energies. It is also seen that some of the coated fabrics showed surface damage even at these low calories levels, but the extent of damage could not be determined by visual inspection. It is particularly interesting to note that the pine panels continued to blister even at these low intensities. It would be of value to find out whether the fire retardant paint would eliminate the blistering of these paint panels.

It had been originally planned to include magnesium in the surfaces to be tested, but it was eliminated due to program restructions. In view of the expanding use of magnesium as a replacement for heavier materials in the construction of airborne and other equipment, and the inability to predict the behavior of paint systems applied to different metals, it becomes increasingly desirable to obtain data on the effect of these phenomina on paint systems coated on magnesium surfaces.

4.3 ERDL EVALUATION TESTS

In the evaluation of the test data of this project is is immediately seen that a larger number of samples would have given more definite results, and that the results obtained do show trends from which valuable conclusions may be drawn.

4.3.1 Paint Systems

Tables C.6, C.7, and C.8 Appendix C, show the effect of varying intensities of thermal flux on the resistance of these coatings to salt air, high humidity and accelerated weathering. It is shown that, in general, the exposed panels have poorer flexibility abrasion resistance and shear hardness than the unexposed panels, with the amount of damage increasing with the increase in thermal flux. This table shows that the alkyd system shows less damage over steel while the phenolic system is best over aluminum; with the epoxy resin system showing no particular differentiation. This shows that the effect on one coating system cannot be used to predict the damage that will be done to another. The vinyl paint was exposed on steel alone, therefore no comparison can be made of its characteristics on steel and aluminum. It is noted, however, that it suffered less damage than the other paint systems. This is attributed to its higher reflectivity. It was a white paint while the others were O.D. in color.

A study of Tables C.10, C.11 and C.12 shows that the overall flexibility of the different systems is not particularly affected by low intensities but that a thermal flux of 10 to 18 cal/cm^2 causes a small improvement in this property. This may be attributed to a heat polymerization of the paint, resulting in a tougher film. It is also noted that the overall abrasion resistance shear hardness show decreasing resistance with increase in thermal flux. An exception to this trend is the shear hardness of the vinyl system. These panels have very good shear hardness at energies up to 10 cal/cm^2 but have a sharp breakdown at 18 cal/cm^2. This indicates a critical energy at some point within this range.

Table C.4 Appendix C, shows the effect of exposing alkyd, phenolic epoxy and vinyl systems to a thermal flux of 85 cal/cm^2. It is noted that the paint is completely destroyed on all of the panels and most of them show severe sand erosion. In order to determine whether there was any surface effect not readily noticeable, these panels were placed in a high humidity cabinet along with a simular uncoated metal panel. The results of this exposure are shown in Table C.9, Appendix C. It is seen from this table that the exposed panels had improved resistance to rust and corrosion. It is believed that some of the paint pigments, such as the lead, zinc or chromate were reduced and fused into the surface of the panel making it more resistant.

Table C.13 shows the effect of different intensities of thermal flux on the fire retardant properties of ordinary house paint and fire retardant paint developed by ERDL. Based on the results obtained from this test, it can be seen that exposure to low intensities of thermal flux tends to improve the fire retardant properties of the paint. This can be accounted for by the heat polymerization of the oils and resins, making them harder and less combustible under laboratory test. It is also shown that the different levels of exposure do not significantly affect the weight loss of either paint. A difference is noted, however, in the char volume (amount of char on underlying wood panel) of the two paints. Up to a thermal level of 10 calories, the house paint shows an increase in char volume with an increase in thermal intensity while the fire retardant paint shows a decrease. This would indicate that the house paint is progressively breaking down to permit more and more destruction of the underlying wood while the fire retardant paint is developing more and more of a protective barrier that permits less and less destruction. It is also interesting to note that after exposure of 85 cal/cm^2, the poplar panels had all of the paint either burnt off, or worn off from sand abrasion. Under visual inspection both panels appeared to be identical in serviceability, however, an examination of Table C.13 shows that the panels coated with ordinary house paint were completely destroyed while the ones with the fire retardant paint suffered a moderately severe char but remained intact. This indicates that structures coated with ordinary paint would have burned down while those coated with fire retardant paint would have received a bad char but would remain standing and intact. Figures 4.2 and 4.3 show the effect of thermal flux on these two paints and their resistance to burning.

4.3.2 Plastics and Coated Fabrics

An examination of Table C.14 Appendix C, shows that, in general, thermal flux intensities up to 18 cal/cm^2 have only a slight effect on the flexural strength, modulus of elasticity, and surface hardness of the rigid plastics. The percent of light transmittance was determined to evaluate the use of these materials for windows, skylights, etc. It is to be seen that no great amount of damage was done at levels up to 9.6 cal/cm^2 but that a sharp drop occurred around 18 cal/cm^2 indicating a critical energy value in this range. A visual examination of the cellulose acetate, polyester resin, and polyvinyl chloride show that these samples were not uniformly damaged, indicating an unequal exposure to the effects.

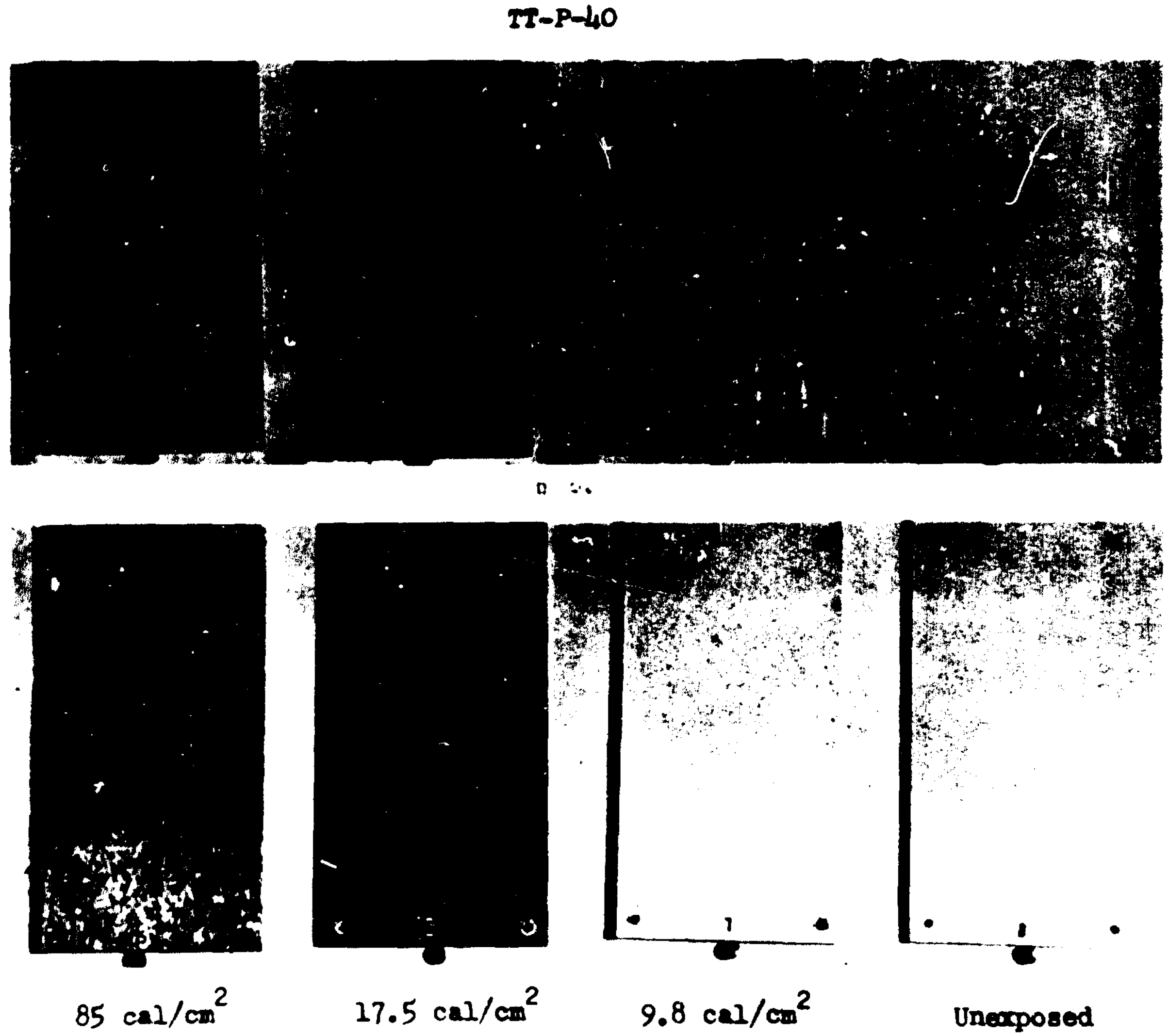


Fig. 4.2 Effect Of Thermal Flux Outside White Paint (FS. TT-P-40) And A Fire Retardant Paint (VV Ext. 20)

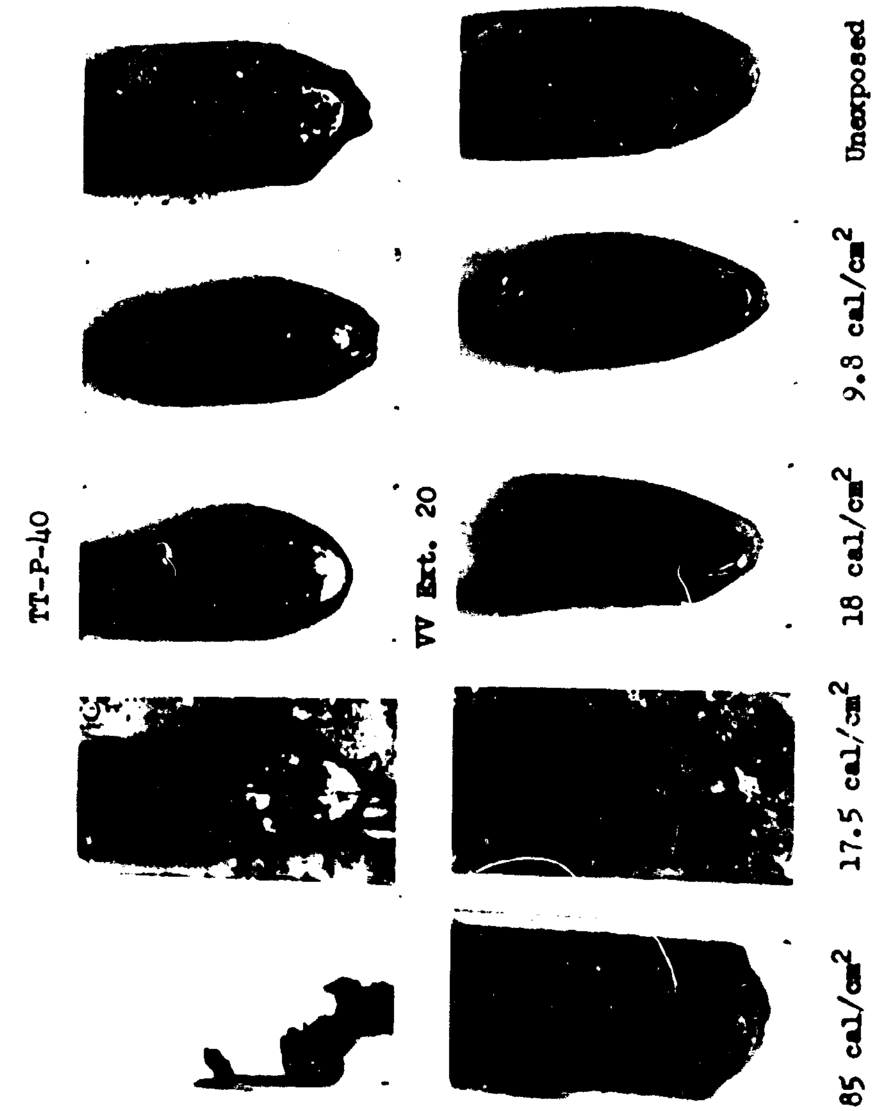


Fig. 4.3 Fire Retardancy Test Under FS. TT-P-26 After Exposure To Thermal Flux

It can be concluded from these results that, with the exception of the light transmittance properties, thermal flux up to 18 cal/cm^2 will not seriously affect the use of these rigid plastics. The fact that fiberglass reinforcing material made a good showing in both the rigid plastic and fiber uses indicates a desirability of further testing this material. Table C.15 Appendix C show the effect of thermal flux on the physical properties of certain plastic films. It is to be noted that the films in general showed poor resistance to even moderate levels of thermal flux. It is quite probable that this poor showing is a result of the combination of blast and thermal damage. Teflon showed destruction around 10 cal/cm^2 in the field test and a critical energy of 55 cal/cm^2 under the NML tests. It is also seen that the saran film showed a marked increase in Specific Gravity (density). This can be accounted for by the loss of plasticizer and other volatile constituents.

Table C.16 and Figure C.2 Appendix C, shows the effect of thermal flux on the physical properties of certain plastic and cotton fibers. The breaking strength was determined on both the straight and knotted strands since a large requirement for these materials is in the manufacture of camouflage netting. It has been shown by previous experience that knotting has a definate effect on the tensile strength of the fiber. The straight strand fibers show little change in breaking strength up to 9.6 cal/cm^2 with destruction of 18 cal/cm^2. The vinyl covered fiberglass is an exception to this trend showing little loss of strength at any level. The saran fiber, on the other hand, was destroyed at 5.6 cal/cm^2. The tensile strength of the knotted strands, while less than that of the straight fibers showed the same general trend. On the basis of these results, it can be concluded that the vinyl covered fiberglass should be usable after exposure to 18 cal/cm^2 of thermal flux, in orlon, cotton, and Nylon FM 3606 up to an intensity of 8 cal/cm^2, and the Dynel and untreated nylon to 5 cal/cm^2. Saran will be damaged at 3 cal.

Tables C.17 and C.18 and Figure C.3 Appendix C, show the effect of different levels of thermal flux on the physical properties of certain coated fabrics. It is shown that low intensities cause little or no damage to the tensile strength and elongation with some of the samples even showing a slight improvement; while 18 cal/cm^2 will completely destroy or severely damage the fabric. It is to be noted from the table that the untreated duck shows destruction above 9.6 cal/cm^2 and the laboratory coated sample of neoprene above 5.6 cal/cm^2. It is significant to note that all of

the coated fabric samples except the neoprene sample had been flame proofed before coating. This at least, in part, accounts for their higher critical energies.

An examination of Fig. C.3 shows that there was varying amounts of visual damage to the different samples. The test results in the above tables show that at intensities up to 9.6 calories, the damage is largely a surface damage which has not hurt the fabric itself but that thermal levels in the range of 18 calories will destroy or seriously damage the fabric itself. This is another example of the need of subsequent testing of physical properties in correctly evaluating the effect of these phenominee on the service life and use characteristics of the various materials.

Additional, more detailed, test data and photographs not included in this report are on file in the Materials Laboratory, ERDL and are available for inspection by any interested persons.

4.4 COMPARISON OF LABORATORY FLUX AND FIELD EXPOSURE TESTS

The object of establishing a correlation between laboratory flux and field exposure effects is to establish a method of screening the different materials in order to pick the most promising ones for field exposure. A study of Table C.19 reveals that, in general, the field exposure was more severe than the laboratory flux. Two exceptions to this are: 1. The phenolic system on steel, which showed slightly more damage in the laboratory, at the lower calorie intensities and about the same at the higher intensities. 2. The phenolic system on wood, which consistently showed more damage from the laboratory flux. It is also interesting to note that there was moderate to deep char of the resinous grain of the wood panels, subjected to field exposure, while the non-resinous grain showed little if any char. This condition was not noted in the laboratory samples possibly due to the size of the sample and smallness of the exposed area. It is believed that these test data show a fair correlation with the field exposure. The following factors make a comparison more difficult:

a. The small number of samples of each system exposed. Where visual conclusions are drawn from a small number of samples or from a small area on a panel, the probability of error is increased because there is no chance for small differences in apnel preparation or exposure conditions to be averaged.

b. The difference in the sizes of the exposed areas. The field samples had an area of [illegible]4 sq. in. as compared to 0.02 sq. in. (10 sq.mm.) for the laboratory samples.

c. While the laboratory samples were subjected to thermal flux alone the field samples were exposed to both thermal flux and blast damage with the blast damage possibly obscuring any light surface char.

d. The apparent non-uniformity of thermal damage by increasing intensities of laboratory thermal flux.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

It is concluded that:

1. Visual inspection alone, does not give a true picture of the damage done and that subsequent laboratory testing of the physical properties is necessary for the accurate effective evaluation of the damage done to exposed materials.

2. Certain paint systems sustain different degrees of damage when coated over different metal surfaces, and that the effect of the metal surface on the damage to one coating system was not in direct correlation with the effect on other types of coating systems.

3. That paint systems applied to metal surfaces, although completely destroyed by exposure to high intensities of thermal flux, will impart improved rust and corrosion resistance to these surfaces, even under high humidity conditions.

4. Wood panels coated with an adequate fire retardant paint have a critical energy for wood charring seven times that of the unpainted wood and twice that of normally used house paint.

5. The fire retardant paint, even though completely destroyed by high thermal intensity and blast damage, imparted to the underlying wood a good resistance to burning not found in a similar wood panel coated with house paint.

6. The rigid plastics show little damage at intensities below 18 cal/cm^2 with light transmittance being the only property showing any appreciable change and that plastic films and fibers in general, are destroyed at critical energies in the range of from 8 to 12 cal/cm^2.

7. Laboratory tests show that the damage to the coated fabrics at intensities up to 10 cal/cm^2 is a surface effect that does not injure the fabric itself but that intensities of 18 cal/cm^2 will severely damage the fabric.

8. Flame proofing of the coated fabrics prior to coating will decrease the damage caused by exposure to these phenomena.

9. The epoxy resin system is equally good when coated on steel or aluminum while the alkyd system suffered less damage when coated over steel, and the phenolic system less damage when coated over aluminum.

10. Resinous type wood (pine) will blister even at low thermal intensities irrespective of the coating system used.

11. Laboratory exposure tests show that materials having high transparency or reflectivity show high critical energies.

12. Materials having high reflectivity or absorption characteristics offer better protection to the underlying material than those with high transparency.

13. Of the rigid plastics exposed to laboratory flux the polyester-fiberglas type offers the best protection to the underlying material even at high thermal ranges.

5.2 RECOMMENDATIONS

It is recommended that:

1. Critical wood structures, subject to atomic blast exposure, be coated with an adequate fire retardant paint.

2. Epoxy resin type finishes be considered for use on metal equipment subject to these conditions.

3. The polyester-fiberglas type of plastic be used where there is a need for a non-transparent rigid plastic with a high resistance to thermal flux.

4. All coated fabrics be flame proofed before coating.

5. Further study be made on fire retardant paints to determine whether such paints formulated to an O.D. or camouflage color would have the same protective properties as the paint evaluated in this program.

6. A study be made, at some future test, to determine the effect of these phenomina on coatings applied to magnesium surfaces.

This data will be of increasing value due to the expanding use of magnesium in air-borne and other equipment.

7. Further work be done to evaluate the effect of thermal flux on single and multiple coat systems to determine whether the damage is a surface effect or whether it sets up thermochemical reactions in the undercoats affecting their service life.

8. Additional work be done on woven fibers of the camouflage net and garnishment type to determine the effect of these phenomena on the camouflaging properties as well as the physical characteristics of these fibers.

9. Further exposures be made on the plastics and coated fabrics in the range of 10 to 20 cal/cm^2. This was shown to be a critical range for a number of the samples.

BIBLIOGRAPHY

1. Protective and Decorative Coatings
J. J. Mattiello - John Wiley and Sons

2. F. J. LeQue
International Nickel Company
New York, New York

3. ERDL Report #1226, Fire Retardant Paints and Paint Systems
Harvey Miller

4. Effects of Atomic Weapons
Government Printing Office

APPENDIX A

PREPARATION OF TEST SAMPLES

A.1 PREPARATION OF SAMPLES FOR NML EXPOSURE

A.1.1 Preparation of Paint Samples

TABLE A.1

Coding of Paint Samples Prepared for NML Testing

System No.	Type Panel	Primer Coat	Finish Coat
1	Steel	MIL-P-15328[1]	
		TT-E-485	TT-E-485
2	Aluminum	"	"
3	Magnesium	"	"
4	Wood	TT-P-636	3-174
5	Steel	MIL-P-15328	
		TT-E-485	3-173
6	Aluminum	"	"
7	Magnesium	"	"
8	Wood	TT-P-636	
		3-174	"
9	Steel	MIL-P-15328	
		TT-E-485	TT-E-489
10	Aluminum	"	"
11	Magnesium	"	"
12	Wood	TT-P-636	"
13	Steel	MIL-P-15328	
		3-193, Type I	3-194
14	Aluminum	"	"
15	Magnesium	"	"
16	Wood	3-193, Type II	"
17	Steel	MIL-P-15328	3-194
		3-193, Type I	3-173
18	Aluminum	"	"
19	Magnesium	"	"
20	Wood	3-193, Type II	"
21	Steel	MIL-P-15328	TT-E-485
22	Aluminum	"	"
23	Magnesium	"	"
24	Wood	TT-P-636	"
25	Steel	MIL-P-15328	
		TT-E-485	3-173

TABLE A.1

Coding of Paint Samples Prepared for NML Testing
(conti)

System No.	Type Panel	Primer Coat	Finish Coat
26	Aluminum	TT-E-485	3-173
27	Magnesium	"	"
28	Wood	TT-P-636	"
29	Steel	Pigmented Epon[2]	Pigmented Epon
30	Aluminum	" "	" "
31	Magnesium	" "	" "
32	Wood	" "	" "
33	Steel	MIL-P-15328 Pigmented Devran	" "
34	Aluminum	" "	" "
35	Magnesium	" "	" "
36	Wood	TT-P-636	Pigmented Epon
37	Poplar Wood	TT-P-25	TT-P-40
38	Poplar Wood	"	Fire Retardant Paint, TT-P-26 (Int.)

[1]Under painted panels, the primer and finish refer to Government specifications.

[2]The "Pigmented Epon" is an Epon-resin vehicle pigmented similar to TT-E-485b. It was prepared by Devoe Raynolds Company, Louisville, Kentucky.

Specific paint systems as shown in the above table were prepared by brush coating them on 1" x 8" x 1/8" panels of wood, steel, aluminum and magnesium, and allowing the paint to air dry 20 to 24 hours after each coat. The paint systems on metal were cut to approximately one inch length and the eight pieces mounted on a glass melamine holder with an air space less than 1/16" between each section to eliminate heat conduction between the sections. The systems on wood were mounted in one piece and held in place by insulated retaining strips.

In the preparation and testing of these samples, it became obvious that brush coating of the samples was not a satisfactory

method of application due to the requirements and limitations of the test method. It was seen that small differences that averaged in normal practice on larger surfaces and on the field panels appeared to be intensified in the small surfaces. Future panels should be prepared either by spraying to a specified dry film thickness or by use of the doctor blade techniques. If apparatus for controlled film thickness is available it should be the quickest most efficient method.

A.1.2 Preparation of Plastic and Coated Fabric Samples

TABLE A.2

Coding of Plastics, Coated Fabrics and Packaging Materials for NML Testing

System	Materials Description
1. Plastics	
39	Polystyrene
40	Polyester, reinforced with fiberglas mat
41	Cellulose Acetate
42	Acrylic (Plexiglass)
43	Teflon
44	Saran Sheet
45	Polyethylene
46	Vinyl Sheet
54	Vinyl Covered Glass Fiber
55	Nylon Fiber
56	Dynel Fiber
57	Saran Fiber
58	Nylon Monofilm (FM 3606)
59	Orlon Fiber
60	Vinyon (NOHU)
2. Coated Fabrics	
47	Nitrile Rubber (GR-A)
48	Natural Rubber
49	Vinyl Chloride-Acetate Co-polymer
50	Isobutylene-Isoprene Co-polymer, (GR-I)
51	Neoprene Rubber (GR-M)
52	Uncoated Treated Duck
53	Butadiene-Styrene Co-polymer (GR-S)

TABLE A.2
(conti)

System	Materials Description
3. Packaging Materials	
121-115	JAN-B-121, Grade C, Type I, Class 1, Greaseproof Barrier-Material, coated with JAN-P-115, Dipcoat Sealing Compound.
121-A-II-1	JAN-B-121, Grade A, Type II, Class 1, Greaseproof Barrier-Material.
121-C-I-1	JAN-B-121, Grade C, Type I, Class 1, Greaseproof Barrier-Material.
131A-I-A	MIL-B-131A, Class A, Flexible Water-Vaporproof Barrier-Material.
117-B-I-C	JAN-P-117, Grade B, Type I, Class C, Non-heat Sealable Greaseproof, Waterproof Bag.
149-TY-I	JAN-C-149, Type I, Protective Strippable Compound Ethylcellulose.
149-TY-II	JAN-C-149, Type II, Protective Strippable Compound Acetate Butyrate.
RMH 1756[3]	AXS 1756 Strippable (Sprayable) Protective Compound.
GE-5249[4]	50-5249 by R. M. Hollingshead Corporation No Government specification covering.
————	AXS-673 Hard Drying, Thin Film Preservative coated on 1" x 12" x 1/8" mild carbon steel.

[3] Army Cocoon by R. M. Hollingshead Corp., Camden, N. J. Specification No. 4939 Army Cocoon conforms to AXS 1756.
Film formed by
- 1 coat webbing mixed to Hollingshead Specification.
- 1 coat cocoon consisting of 3 applications (approx. 5 mils ea) mixed with 2 oz yellow dye.
- 1 coat cocoon consisting of 3 applications (approx. 5 mils ea) mixed with 1 lb aluminum paste per gallon cocoon.

[4] G. E. Cocoon by R. M. Hollingshead Corporation, Camden, N. J.
Specification No. 50-5249
No Government Specification covering
formulated expressly for General Electric Co.,
Knolls Atomic Power Laboratory, Schenectady, N. Y.
Approved for use in all AEC establishment by USAEC,
Washington, D. C. and Oak Ridge National Laboratory,
Tennessee. (For use indoors only).
Film formed by
1 coat webbing solution as formulated by R. M. Hollingshead Corporation, Camden, N. J.
2 coats cocoon each consisting of 3 applications (Each application approx. 5 mils thick).

The plastics and coated fabrics as shown in Table A.2 above, were prepared in the following manner.

A.1.2.1 Coated Fabrics and Plastic Film

The coated fabrics and plastic film specimens were cut into 1" x 8" strips and mounted on a glass melamine holder grooved to provide an air background. A glass silicone laminate fire guard, employed to prevent the propagation of a flame, was mounted over the specimen and held in place by an insulated strip.

A.1.2.2 Plastic Fibers

The plastic fibers were wrapped widthwise around plywood holders (1 x 8 inches) and held in place by insulated strips. Side notches were utilized to prevent slipping.

A.1.2.3 Packaging Materials

The packaging materials were cut to approximately 1" x 8" and mounted on plywood or glass melamine holders depending on the material. A glass silicone laminate fire guard was utilized on all samples except the ethyl cellulose and the acetate butyrate strippable compounds.

A.1.2.4 Rigid Plastic Material

The rigid plastic material was cut to approximately 1" x 4" size and mounted on a 1" x 8" plywood strip and held by insulated strips. A small space less than 1/16" was kept between the strips to eliminate heat conduction.

A.1.2.5 Different Method of Mounting Samples

Some further thought should be given to a different method of mounting these samples. In several instances more damage was caused from the burning of the backup than from incident radiation. This made it very difficult to evaluate the samples. Improper packaging also caused loss of some samples. Paper and other packaging material stuck to the test face thus altering its surface characteristics. It was noted also that several of the packaging materials had identifying stencil marks on the face of the sample that made their evaluation more difficult. A clearer more detailed knowledge of the requirements and limitations of the method would have eliminated this difficulty

A.2 PREPARATION OF SAMPLES FOR FIELD EXPOSURE

A.2.1 Preparation of Paint Samples

TABLE A.3

Coding of Paint Samples For Field Exposure

Code System	Type Panel	Prime Coat	Finish Coat
C-1	Steel	Wash primer MIL-P-15328	TT-E-485[1] (2 coats)
C-2	Aluminum	Wash primer MIL-P-15328	TT-E-485 (2 coats)
C-4	Wood	TT-P-635	3-174
C-5	Steel	MIL-P-15328 TT-E-485	3-173
C-6	Steel	MIL-P-15328	TT-E-489 (2 coats)
C-7	Steel	MIL-P-15328 TT-E-485	3-194
C-8	Aluminum	MIL-P-15328 3-193-TyI	3-194
C-10	Wood	3-193-Ty II	3-194
C-11	Wood	TT-P-636	TT-E-485
C-12	Steel	Pigmented Epon[4]	Pigmented Epon
C-13	Aluminum	" "	"
C-15	Wood	" "	" "
C-16	Steel	MIL-P-15328 Pigmented Epon	" "

TABLE A.3
(conti)

Code System	Type Panel	Prime Coat	Finish Coat
C-17	Poplar Wood	TT-P-25	TT-P-40 (2 coats)
C-18	Poplar Wood	TT-P-25	VV-Ext 20[2] (2 coats)
C-20	Steel	Vinyl Paint[3] Prime Coat (1 coat)	Vinyl Paint Body Coat (2 coats)

[1] The primer and finish coats refer to Government specifications.

[2] VV Ext 20 is an experimental fire retardant paint developed under research contract by Vita Var Corp., Newark, N. J.

[3] The vinyl paint is Amercoat 23, a commercial coating produced by Amercoat Corp., Los Angeles, California

[4] Epon resin paint is an Epon type vehicle pigmented similar to TT-E-485b and was manufactured by Devoe Raynolds Co., Louisville, Kentucky.

Representative paint systems as shown in Table A-3 were prepared as follows.

A.2.1.1 Cold Rolled Steel Panels

7" x 12" SAE 1020 cold rolled steel panels were sand blasted, solvent cleaned and coated as shown in the above table.

A.2.1.2 Aluminum Alloy Panels

7" x 12" x 0.04" 24ST3 aluminum alloy panels were solvent cleaned and coated in accordance with the above table.

A.2.1.3 Southern Yellow Pine Wood Panels

6" x 12" x 3/8" southern yellow pine wood panels were sanded smooth and free from dirt, and coated in accordance with the above table.

A.2.1.4 Poplar Wood Panels

Poplar wood panels conforming to the requirements of Fed. Spec. TT-P-26 were coated as shown in the above table.

All coatings were sprayed to give a total dry film thickness of 3.5 to 4.0 mils. All systems except C.12, C.13, and C.16 were air dried. These systems were baked for 15 minutes at 250° F. A steel backup plate 7" x 12" x 1/16" was used on all of the samples to minimize destortion from blast effects.

In future tests it would be desirable to investigate the use of standard gauge panels and to use a controlled film thickness spray apparatus for coating the panels.

A.2.2 Preparation of Plastic and Coated Fabric Samples

The following table lists the samples subjected to field exposure.

TABLE A.4

Coding System for Plastics and Coated Fabrics for Field Exposure

System	Material Description
1. Rigid Plastics	
P-1	Plexiglass
P-2	Cellulose Acetate
P-3	Polyester Resin (Glass Mat)
P-4	Phenol-Formaldehyde (Asbestos)
P-5	Polyvinyl Chloride
P-6	Polyethylene
P-7	Teflon
P-8	Vinyl Sheet
P-9	Saran
P-10	Dynel
P-11	Orlon
P-12	Cotton
P-13	Vinyl Covered Glass
P-14	Nylon
P-15	Saran
P-16	Nylon Monofilm (FM-3606)

TABLE A.4
(conti)

System	Material Description
2. Coated Fabrics	
CF-1	Butadiene-Styrene Copol. (GR-S)
CF-2	Isobutylene-Isoprene Copol. (GR-I)
CF-3	Neoprene GN
CF-4	Uncoated Treated Duck
CF-5	Nitrile Rubber GR-A
CF-6	Natural Rubber
CF-7	Vinyl Chloride-Acetate Copol.
CF-8	Neoprene Rubber Lab. batch

All of the samples were mounted on 1/4" plywood panels, 15" by 13", built up on the ends to permit a 1" air space between the sample and the backup panel. The fibers were strung in parallel strands running the length of the panel. The rigid plastic samples had nail holes drilled into each end of the sample so that the nails used for fastening the samples would not cause any localized stresses in the material. All of the coated fabric samples were commercial products except the neoprene coated fabric which was coated in the laboratory at ERDL.

In future tests thought should be given to the replacement of the wood backup panels with a non-flammable non-conductive type. This would eliminate damage from panel burn and simplify the evaluations.

A.3 CONSTRUCTION OF RACKS FOR FIELD TESTS

A.3.1 Construction of the Test Racks

The test racks, Fig. A.1 were constructed of 3/8" angle iron with two removeable panel holding sections, and hinged back braces that permitted the face of the rack to be set at any angle from 90° to 180°, and were bolted to steel stakes set into the ground. To determine the best method of setting the stakes, they were set in three different ways.

a. Set in concrete (6" thick, 18" diameter)

b. Set in the ground with an 18" baffle plate affixed near the bottom of the stake and the dirt backfilled over it.

c. The stake merely driven into the ground.

Fig. A.1 Construction Of Racks Used For Field Exposure

The rack, itself, was 5' x 10' with two 3' x 5' panel sections that were 2' off of the ground. The rack and panel sections were so constructed that they reinforced each other. The panel sections were secured to the rack frame by three bolts, thus permitting quick easy removal of the samples to an uncontaminated area where a careful examination of the panels could be made and a fresh series prepared for the next shot.

A 3/4 ton power truck was used to transport the samples to and from the test site. A rack was built on the back of the truck in order to stand the panel sections on edge and space them so that none of the samples would be damaged in transit.

In a study of the results of the exposures on this project it becomes apparent that it would be desirable to be able to differentiate between the damage caused by thermal flux and that

caused by thermal flux and blast damage together. This could be accomplished by either of three modifications of the presently used exposure racks.

a. The use of quartz or "Pyrex Vycer" windows.

b. An electromically operated shield, or one with a fusible metal link, that would drop down and cover the samples, after exposure to the thermal effects and before the arrival of the blast wave.

c. Have the rack so hinged that it would lay back on the ground, with a shield covering the panels, on the arrival of the blast wave.

Quartz windows are commonly used but because of the size and number of samples, the cost would be too great. "Pyrex Vycer" is a glass manufactured by Corning Glass Works, with properties simular to quartz. It is comparatively cheaper than quartz and can be manufactured in desired sizes and shapes. It would warrent further investigation. Method c would have one advantage in that the racks would not have to be built to withstand the pressures required under a or b.

An improvement of the present rack would be a quicker method of fastening the sample panels to the panel sections. At present there are four bolts to each panel and thirty-two paint panels to a rack. However, these can be put on at leisure and kept covered until ready for exposure.

APPENDIX B

METHOD OF EVALUATION OF TEST RESULTS

B.1 METHOD OF EVALUATION OF NML SAMPLES

The samples prepared as described in Appendix A were subjected to a laboratory source of thermal flux using the searchlight method as described in NML BUSTER report No. WT311. In this method, the beam of a 24 inch Navy searchlight is directed towards a receiving mirror which concentrates the energy at a focal point. The sample is made to pass through this point at a constant acceleration or deceleration, with the total flux and the time of exposure determining the amount of flux at any point. The energy level is determined by placing calibration strips along the side of the sample and converting the speed of travel into thermal energy in cal/cm^2.

B.1.1 Method of Evaluating Damage

The general method of evaluating the damage to the specimens was as follows.

B.1.1.1 Evaluating Exposed Paint Systems On Metal

The exposed paint systems on metal were evaluated for initial effects, and the flaming and complete destruction of the paint. Flaming was observed directly during exposure. Complete destruction was the minimum energy at which the charred paint lost its cohesiveness and could be readily flaked off down to the metal surface by lightly scraping with a razor blade.

B.1.1.2 Evaluating Paint Systems On Wood

The paint systems on wood were evaluated for initial effects, paint char, and wood char. The initial effect was primarily the discoloration of the topcoat.

B.1.1.3 Evaluating Exposed Coated Fabrics and Plastic Films

The exposed coated fabrics and plastic films were evaluated for initial effects, charring and destruction. In several cases only one critical point could be recorded, the destruction of the material. The energy corresponding to destruction was taken as the minimum energy at which the charred material lost its cohesiveness and readily fell apart at a light touch.

B.1.1.4 Evaluation Of Plastic Fibers

Plastic fibers were evaluated as to destruction only. Destruction was that point at which the fibers parted.

B.1.1.5 Evaluation of Rigid Plastics

Rigid plastics were evaluated as to the critical points particular to each.

B.1.1.6 Evaluation Of Packaging Material

The packaging material evaluation consisted of determining the energies corresponding to initial effect, charring or melting and destruction.

B.2 ERDL LABORATORY EVALUATION TESTS

B.2.1 Discussion of Test Methods

B.2.1.1 Paint Test Methods

The following exposure and evaluating tests were chosen to show what effect the field exposures had on the service life and use characteristics of the different paint systems. A more detailed discussion of them will be found in Fed. Spec. TT-P-141.

The Salt Spray Cabinet Test is one in which the samples are exposed to a fog of 20% salt solution at 90° F and was used to evaluate the porosity of the film and its ability to prevent corrosion of the underlying surface.

The Accelerated Weathering Test is one in which the samples are subjected to cycles of ultra-violet light (carbon arc) and water spray. It was used to evaluate the service life left in the film, that is, how well it would continue to stand up in outside use.

The Humidity Cabinet Test is one in which the sample is subjected to conditions of high humidity (90° F and 95% R.H.) and was used to evaluate the porosity of the film and its ability to protect against rusting in high humidity (tropical) conditions.

Flexibility, abrasion resistance and shear hardness were used to evaluate the effect of the above exposure tests. Flexibility indicates adhesion of the film to the surface and resistance to thermal shock. It is determined on the Navy conical mandrel and is calculated to per cent elongation of the film by the following

formula: $\% = 100\frac{T}{2r + T}$

where T = average thickness of the panel (inches)
r = radius of incipient cracking.

Abrasion resistance indicates the resistance of the film to abrasive wear. It is determined as weight loss on the Tabor Abrader and calculated to volume loss of the paint film.

Shear hardness indicates the adhesion and cohesion of the paint film and its resistance to gouging and mechanical shock. It is determined on the Tabor Abrader and is reported as the average width of scratch, in 10^{-3} inches, made with a 600 gram load.

B.2.1.2 Plastics and Coated Fabrics

The non-volatile (ash) content of the reinforced plastics was determined by ashing at 1050° F. An increase in non-volatile would indicate the loss of plastic binder.

The surface hardness was determined on the "M" scale of the Rockwell Hardness Tester in accordance with Method 1081 Fed Spec. L-P-406a. A change in hardness indicates an increase in the polymerization of the material or a loss of plasticizer.

The specific gravity was determined on a Jolly Balance, in accordance with Method 5011, Fed. Spec. L-P-406a. An increase in specific gravity is an indication of the loss of some of the volatile constituents.

The breaking strength of the fibers and coated fabrics was determined on the Scott Tensile Tester in accordance with Method 5102, Fed. Spec. CCC-T-1916. Both the "strand strength" and "knot strength" were determined on the fibers since it has been shown that knotting has a variable effect on the strength of the fibers which is significant when the fibers are used in camouflage materials.

The flexual properties and modulus of elasticity of the rigid plastics were determined in accordance with Method 1031 Fed. Spec. L-P-406a. This test indicates the ability of the rigid plastic to resist breaking under bending stresses.

The percent light transmittance was determined on the G. E. Recording Spectrophotometer in accordance with Method 425.1 Fed. Spec. TT-P-141b. This test indicates any loss in translucency or the ability of the material to transmit light.

B.3 METHOD OF EVALUATING DAMAGE TO SAMPLES, ERDL

B.3.1 Paint Samples

B.3.1.1 Exposure of Metal Panels

The metal panels were cut to 4" x 4" and 3" x 5" sizes, properly edged and subjected to the following exposure tests.

150 hours - Salt Spray Cabinet

300 hours - Accelerated Weathering

30 days - High Humidity

These panels were then evaluated for flexibility, abrasion resistance and shear hardness.

B.3.1.2 Exposure of Paint Systems

The panels on which paint systems were exposed to 85 cal/cm^2 and apparently suffered total destruction, were subjected to 30 days in the humidity cabinet.

B.3.1.3 Exposure of Fire Retardant Panels

The fire retardant panels, C.17 and C.18 were conditioned and burned by the Cabinet Test Method as specified in Fed. Spec. TT-P-26.

B.3.2 Plastics and Coated Fabrics

B.3.2.1 Rigid Plastics

The rigid plastics were subjected to the following laboratory tests.

Flexual strength and modulus of elasticity

Specific Gravity

Rockwell Hardness

Light Transmittance

Percent Inert

B.3.2.2 Plastic Film and Coated Fabrics

Plastic films and coated fabrics were subjected to the following laboraoty tests.

Breaking Strength

Percent elongation

B.3.2.3. Fibers

Fibers were subjected to the following laboratory tests.

Breaking strength, strand and knot

Percent elongation, strand and knot

APPENDIX C

TABLE C-1

The Effect of Laboratory Thermal Flux on Certain Materials

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
1	Alkyd lusterless enamel (2 coats) on steel.	Dulling and darkening of surface.	7.9
		Surface breaks into non propagating flame.	16
2	Alkyd lusterless enamel (2 coats) on aluminum.	Dulling and darkening of surface.	19
		Surface breaks into non propagating flame.	38
3	Alkyd lusterless enamel (2 coats) on magnesium.	Dulling and darkening of surface.	6.3
		Surface breaks into non propagating flame.	16
		Paint Carbonizes exposing metal on light scraping.	30
4	Alkyd Semi-gloss enamel on wood.	Blistering of topcoat.	1.4
		Discoloration of topcoat.	1.8
		Topcoat Chars.	5.5
		Undercoat Chars.	13
		Wood Browns.	14
		Wood Chars.	17
5	Alkyd Semi-gloss enamel on steel.	Paint turns rusty red color.	19
6	Alkyd Semi-gloss enamel on aluminum.	Paint turns rusty red color.	15
7	Alkyd Semi-gloss enamel on magnesium.	Paint turns rusty red color.	10
		Surface breaks into non propagating flame.	14
		Paint carbonizes and flakes off exposing metal on light scraping.	19

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
8	Alkyd Semi-gloss enamel on wood .	Discoloration of topcoat. Topcoat Chars. Undercoat Chars. Wood Chars.	1.5 2.7 7.0 13.0
9	Alkyd Gloss enamel on steel.	Paint turns rusty red color.	19
10	Alkyd gloss enamel on aluminum.	Paint turns rusty red color.	28
11	Alkyd gloss enamel on magnesium.	Paint turns rusty red color. Surface breaks into non propagating flame. Paint carbonizes and flakes off exposing metal on light scraping.	6.7 16 33
12	Alkyd Gloss enamel on wood.	Blistering of topcoat along grain line. Discoloration of topcoat. Topcoat Chars. Undercoat Chars. Wood Chars.	1.0 1.2 2.7 4.6 12
13	Phenolic Paint on steel.	Paint blackens.	7.2
14	Phenolic Paint on aluminum.	No effect.	53

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/cm^2
15	Phenolic Paint on magnesium.	Paint turns rusty red color.	7.9
		Surface breaks into non propagating flame.	13
		Paint carbonizes and flakes off exposing metal on light scraping.	29
16	Phenolic Paint on wood.	Discoloration of top-coat.	1.8
		Topcoat Chars.	3.7
		Undercoat Chars.	8.7
		Wood Chars.	14
17	Alkyd Semi-gloss over Phenolic system on steel.	Paint blackens.	14
18	Alkyd Semi-gloss over Phenolic system on aluminum.	Paint turns a rusty red color.	7.3
19	Alkyd Semi-gloss over Phenolic system on magnesium.	Paint turns a rusty red color.	10
		Surface breaks into non propagating flame.	14
		Paint carbonizes and flakes off exposing metal on light scraping.	15
20	Alkyd Semi-gloss over Phenolic system on wood.	Discoloration of top-coat.	2.3
		Topcoat Chars.	8.2
		Undercoat Chars.	15
		Wood Chars.	22
21	Alkyd lusterless enamel (1 coat) on steel.	Paint blackens.	8.8

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
22	Alkyd lusterless enamel (1 coat) on aluminum.	Paint blackens.	43
23	Alkyd lusterless enamel (1 coat) on magnesium.	Small blisters on surface. Paint blackens. Surface breaks into non propagating flame. Paint carbonizes and flakes off exposing metal on light scraping.	8.8 16 27 33
24	Alkyd lusterless enamel on wood.	Blistering of topcoat. Topcoat Chars. Undercoat Chars. Wood Chars.	1.4 2.3 8.1 10
25	Alkyd Semi-gloss on steel.	Paint turns a rusty red color.	7.9
26	Alkyd Semi-gloss enamel on aluminum.	Paint turns a rusty red color.	7.2
27	Alkyd Semi-gloss enamel on magnesium.	Paint turns a rusty red color. Surface breaks into non propagating flame. Paint carbonizes and flakes off exposing metal on light scraping.	10 16 33
28	Alkyd Semi-gloss enamel on wood.	Blistering of topcoat. Discoloration of topcoat. Topcoat Chars. Undercoat Chars. Wood Chars.	1.5 2.4 3.8 14 23
29	Epon resin paint (2 coats) on steel.	Paint blackens.	8.9

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
30	Epon resin paint (2 coats) on Alumin.	Paint blackens. Surface breaks into non propagating flame.	6.7 15
31	Epon resin paint (2 coats) on magnesium.	Paint blackens. Paint forms brittle blisters which flake off exposing metal.	9.2 14
32	Epon resin paint (2 coats) on wood.	Discoloration of topcoat. Topcoat Chars. Wood Chars.	2.0 3.7 16
33	Epon resin paint over washprimer on steel.	Paint blackens.	10
34	Epon resin paint over washprimer on aluminum.	Paint blackens.	7.9
35	Epon resin paint over washprimer on magnesium.	Paint blackens. Surface breaks into non propagating flame. Paint Carbonizes and flakes off exposing metal on light scraping.	14 16 24
36	Epon resin paint over woodprimer on wood.	Discoloration of topcoat. Topcoat Chars. Undercoat Chars. Wood Chars.	0.93 2.7 5.7 18

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
37	Outside barracks paint on poplar wood.	Blistering of topcoat.	10
		Discoloration of topcoat.	14
		Topcoat Chars.	18
		Wood Chars.	34
38	Fire retardant paint on poplar wood.	Blistering and discoloration of topcoat.	10
		Sporatic charring of topcoat.	16-21
		Topcoat Chars.	21
		Wood Chars.	66
		Undercoat Chars.	81
	Douglas Fir, Uncoated.	Slight charring.	4.5
		First grain Char.	8.3
		Second grain Char.	10
	Poplar wood, Uncoated.	Slight charring.	5.7
		Wood Chars.	8.9
39	Polystyrene.	Not run.	
40	Polyester reinforced with fiberglass mat.	Charring begins, no effect on wood.	28
41	Cellulose Acetate.	Wood Chars.	7.2
		Slight melting.	63
		Destruction.	135
42	Plexiglass.	Wood Chars.	6.5
		No other apparent critical points.	
43	Teflon.	Destruction.	55
44	Saran Sheet.	Destruction.	7.6
45	Polyethylene.	Destruction.	30

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
46	Vinyl Sheet.	Charring begins.	2.3
47	GR-A Rubber.	Slight discoloration.	3.4
		Slight Blackening.	4
		Grey discoloration.	4.8
		Charring begins.	8.4
		Destruction.	9.4
48	Natural Rubber.	Slight discoloration.	0.81
		Brown discoloration.	2.8
		Grey discoloration.	4
		Charring begins.	8.3
49	Vinyl rubber.	Slight discoloration.	1.1
		Sporatic charring.	2.8
		Charring.	4.5
50	GR-I rubber.	Slight discoloration.	0.45
		Grey discoloration	0.73
		Dk. green discoloration.	2.9
		Charring begins.	4.5
51	GR-M rubber.	Slight discoloration.	0.45
		Grey discoloration.	0.74
		Brown discoloration.	1.9
		Charring begins.	2.5
52	Uncoated Duck.	Slight discoloration	1
		Destruction	27
53	GR-S rubber	Slight discoloration.	0.81
		Charring begins.	2.2
54	Vinyl covered glass fiber.	Charring begins.	7
		Destruction begins.	58
55	Nylon fiber	Melting begins	7
		Destruction begins	21

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
56	Dynel fiber	Charring begins. Destruction.	5 9
57	Saran fiber	Charring begins. Destruction.	2.8 5.5
58	Nylon monofilm FM 3606	Destruction	8
59	Orlon	Destruction.	32
60	Vinyon (NOHU)	Destruction.	8.4
121-115	Barrier Material	Slight discoloration. Melting begins.	6.3 8.1
121-C-I-I	Barrier Material	Slight discoloration Charring begins.	4.8 9.4
121-A-II-I	Barrier Material	Slight discoloration. Charring begins Destruction	3 5.8 9.4
131A-I-A	Barrier Material	Melting begins Charring of underlayer Destruction	3.2 7 14
117B-I-C	Waterproof bag	Slight discoloration. Charring begins. Discoloration of underlayer. Destruction top layer. Destruction of underlayer.	2.8 5.9 11 14 27
149-I	Ethylcellulose	Melting begins	5 (approx.)
149-2	Acetate-Butyrate	Melting begins	5 (approx.)

TABLE C-1 (Cont.)

System	Material	Description of Effect on Material	Critical Energy Cal/Cm^2
RWH 1756	Army Cocoon	Slight discoloration Charring begins	2.4 10
GE 5249	G.E. Cocoon	Melting begins Charring begins	5 19
AXS-673	Packaging material	No apparent critical points.	

TABLE C-2

Thermal and Blast Data (Field Exposures)

Stations	BAKER			DOG		
(Nom. ft.)	Slant Distance	Thermal Cal/Cm^2	Blast psi	Slant Distance	Thermal Cal/Cm^2	Blast psi
2000	2414	17.5	5.7	2480	85	9.5
4000	4283	5.0	2.6			
5000	5260	3.2	2.0	5249	18.5	3.8
7000	7230	1.6	1.4	7200	9.8	2.9
9000				9175	5.7	2.7*
12000				12130	3.3	1.5*

* Estimated values
Slant distance in feet
Blast measurements by Sandia Corporation on Contract to LASb
Thermal measurements by NRDL and NML

BAKER Shot	DOG Shot
Height 1118 ft 140 ft N 13 ft W Size 3.47 KT	Height 1417 ft 56 ft N 36 ft E Size 20.9 KT

TABLE C-3

Thermal Exposure Effects

BAKER Shot				
Material	2000 ft. Station	4000 ft. Station	5000 ft. Station	7000 ft. Station
C-1	Small blisters evenly over the surface. Blisters broken to show pitting. Scattered bits of dirt embedded in the surface.	No apparent change in color of sheen. Some surface erosion and gravel damage. A few fine blisters. Some embedded dust.	No apparent damage. A few scattered bits of gravel embedded in the surface.	Some Smoke damage one panel.
C-2	Surface coat charred and blistered. Thin undercoat possibly wash primer is O.K. Two top coats gone.	A small amount of surface erosion and gravel damage. A few fine blisters. Some embedded dust.	Some of the blisters flaked away exposing panel.	No apparent damage.
C-4	Reddish in appearance. Resinous grain shows deep char. Non-resinous grain no char. Coating completely gone.	Panels show small, medium, and large blisters. Resinous grain is red in color with black blisters. Large blisters flaked off and showing some sand erosion of the panel.	Scattered blisters, small to large.	No apparent damage.

TABLE C-3 (Cont.)

Material	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
C-5	Charring, blistering and flaking. Some damage from flying gravel.	Some surface erosion and an occasional blister. No appreciable amount of embedded dirt.	No apparent damage.	No apparent damage.
C-6	Whole surface charred and blistered. The left side shows the most blast damage.	Very slight darkening in color. No particular surface erosion. Occasional blister. Some embedded dirt.	No apparent damage.	Slight warpage on one panel. A group of what might be blisters on the other panel.
C-7	Surface coat shows mottled appearance of brown, red, yellow, and green with large flakes of blistered material.	No visual damage.	No apparent damage.	No apparent damage.
C-8	Coating charred, fine pitting to show primer, some pitting down to metal.	No change in color. Some gravel damage. Some embedded dirt.	No apparent damage.	No apparent damage.

TABLE C-3 (Cont.)

Material	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
C-10	Mottled appearance on surface. Resinous grain shows charring. Coating completely gone in spots showing uncharred wood.	Panels show small, medium, and large blisters. Large blisters have sloughed off showing a reddish coating underneath. Resinous grain charred. Gravel damage.	Spotted reddening of the surface. Some places show red blisters, others just red spots.	No apparent damage.
C-11	Mottled appearance on surface. Resinous grain shows charring. Coating completely gone in spots showing uncharred wood.	Panel slightly lighter in color. Resinous grain charred. Surface covered with sand. Some blast damage.	Covered with fine blisters in the resinous grain and scattered blisters in the other grain.	No apparent damage.
C-12	Charring and blistering of the film. Some pitting	Some surface erosion. Slight darkening of color. Some embedded dirt.	No apparent damage.	No apparent damage.
C-13	Charring and alligatoring of the surface. Some gravel damage. One side appears to be burnt off.	Show some lightening in color. Considerable blistering and disintegration of the top film. Some embedded dirt.	No apparent damage.	No apparent damage.

TABLE C-3 (Cont.)

Materials	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
C-15	Surface charred. Paint completely gone. Wood charred in resinous grain. Deep char in upper right corner.	Fine to large blisters around the edges. Fine blisters over rest of panel. Large blisters flaked off showing charring of wood underneath. Small amount of embedded dirt.	Covered with fine to medium blisters. Some cracking and peeling.	No apparent damage.
C-16	Surface charring over entire surface. Severe charring down center of one panel. Some gravel damage. Some gravel and dirt embedded in the surface.	No change in color. Few scattered blisters. Some embedded dirt.	No apparent damage.	No apparent damage.
C-17	Surface is covered with a coating of sand and dirt. Coating charred in spots. Appears to be gone on majority of panel.	No apparent damage	No apparent damage.	No apparent damage.

TABLE C-3 (Cont.)

Materials	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
C-18	Black surface char. No appreciable embedded dirt. Some gravel damage.	No apparent damage.	No apparent damage.	No apparent damage.
C-20	Surface alligatoring. Coating appears to have fibers or needle crystals. Coating shot on one edge of one panel.	No apparent damage.	No apparent damage.	No apparent damage.
P-1	Cracked on one edge. Slight bow. Some gravel damage. Backing panel scorched.	No apparent damage.	No apparent damage.	No apparent damage.
P-2	Some scorching. Slight bow. Gravel embedded in one edge. Backing panel scorched.	No apparent damage.	No apparent damage.	No apparent damage.
P-3	One edge smoked up. Slight char on back up panel on the unsmoked side. Slight bow. Some gravel damage.	Some smoking. No apparent damage.	No apparent damage.	No apparent damage.

TABLE C-3 (Cont.)

Materials	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
P-4	Some gravel damage and surface erosion. Some bow. No charring of back up panel.	No apperent damage.	No apparent damage.	No apparent damage.
P-5	Heat scorched on one edge. Some gravel damage. Backing panel scorched.	No apparent damage.	No apparent damage.	No apparent damage.
P-6	Completely gone. Back up panel scorched.	One edge damaged (crumpled). Could have been either blast or thermal effects.	No apparent damage.	No apparent damage.
P-7	Completely gone. Back up panel scorched.	Strip torn. Could be blast damage.	No apparent damage.	Torn. Probably due to blast damage.
P-8	Completely gone. Back up panel shows edge scorching.	Completely destroyed. Scorching on back up panel.	Completely gone. Scorching on back up panel	Completely gone.
P-9	Completely gone. Back up panel shows good scorching.	Material melted and practically gone.	Partially burned.	No apparent damage.

TABLE C-3 (Cont.)

Material	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
P-10	Completely gone. Back up panel shows good scorching.	No apparent damage.	No apparent damage.	No apparent damage.
P-11	Completely gone. Back up panel shows good scorching.	No apparent damag	No apparent damage.	No apparent damage.
P-12	Completely gone. Back up panel shows good scorching.	No apparent damage.	No apparent damage.	No apparent damage.
P-13	Coating burnt off glass fiber. Fiber remains. Back up board was charred.	No apparent damage.	No apparent damage.	No apparent damage.
P-14	Completely gone. Back up panel charred.	No apparent damage.	No apparent damage.	No apparent damage.
P-15	Completely gone. Back up panel charred.	Completely gone.	Melted and frayed.	No apparent damage.
P-16	Completely gone. Back up panel charred.	No apparent damage.	No apparent damage.	No apparent damage.

TABLE C-3 (Cont.)

Material	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
CF-1	Completely gone. Possibly due to blast damage. Slight charring under sample. Good charring between samples.	Some whitening of the surface.	Some whitening. Some surface erosion.	No apparent damage.
CF-2	Some charring of surface. Gravel and dirt embedded in surface. Slight charring under sample.	Some surface erosion. Some embedded dirt.	Some whitening. Some surface erosion.	No apparent damage.
CF-3	Blackened surface. White surface deposit. Slight charring under sample.	Some whitening of the surface. Some surface erosion.	Some whitening. Some surface erosion	No apparent damage.
CF-4	Completely gone. Slight char on back up panel.	Some surface erosion. Some embedded dirt.	Some surface erosion.	No apparent damage.
CF-5	Completely gone. Probably due to blast damage. Slight charring of back up panel.	Some smoking. Some whitening.	No apparent damage	No apparent damage.

TABLE C-3 (Cont.)

Material	2000 ft Station	4000 ft Station	5000 ft Station	7000 ft Station
CF-6	Completely gone. Probably due to blast damage. Slight charring of back up panel.	Some smoking. Some whitening.	No apparent damage.	No apparent damage.
CF-7	Surface blackened. Gravel and dirt embedded in the surface. Very slight charring of back up panel.	Some melting and blackening. Some gravel and dust embedded in the surface.	No apparent damage.	No apparent damage.
CF-8	Completely gone. Back up panel shows slight charring.	Some dirt embedded in the surface. No other apparent damage.	No apparent damage.	No apparent damage.

TABLE C-4

Thermal Exposure Effects

DOG Shot at 2000 Ft.	
Material	Description of Effects
C-1	Paint completely gone. Panel shows heat blueing and excessive sandblasting.
C-2	Paint completely gone. Panal shows excessive sand-blasting. One panel half gone.
C-5	Paint completely gone. Panel shows heat blueing, excessive sandblasting,and gravel damage.
C-6	Paint completely gone. Panel shows heat blueing, excessive sandblasting, and gravel damage.
C-7	Paint completely gone. Panel shows heat blueing, excessive sandblasting, and gravel damage.
C-8	Paint completely gone. One panel completely gone. Second panel shows excessive sand erosion and gravel.
C-12	Paint completely gone. Panels show heat blueing and excessive sandblasting and gravel damage.
C-13	Small specks of what appears to be paint remains. The rest of the panel shows sandblast effects.
C-16	Paint completely gone. Panels show heat blueing, excessive sandblasting, and gravel damage.
C-17	Paint completely gone. Surface shows excessive sandblasting and gravel damage.
C-18	Paint completely gone. Surface shows excessive sandblasting and gravel damage.
C-20	Paint completely gone. Surface has a gray mat appearance.

TABLE C-5

Thermal Exposure Effects

DOG Shot				
Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
C-1	Fine blisters. Some embedded dirt. Some pitting of blisters, particularly on one panel.	Some gravel damage. Small amount of embedded dirt.	No apparent damage.	No apparent damage.
C-2	One panel shows fine blisters and pitting. Other panel shows blistering and flaking. Both grain charred.	Some gravel damage. Small amount of embedded dirt. One or two incipient blisters.	No apparent damage.	No apparent damage.
C-4	Coating gone. Reddish coating on surface of panel. Resinous grain charred.	Charring and blistering in resinous grain. Considerable flaking. Reddish film left on the wood.	Small to large blisters, covering the surface. A number of the blisters on the resinous grain have been charred.	Small to large blisters in resinous grain of the panel. None broken or flaking off.

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
C-5	Blistering and flaking with exposure of panel. Some charring on the edges.	Some gravel damage. Some embedded dirt.	No apparent damage.	No apparent damage.
C-6	Both panels badly charred. One panel shows bad pitting probably due to gravel damage.	Coating completely gone.	No apparent damage.	No apparent damage.
C-7	Paint completely gone. Large blisters flaked off. Red and green spots on the panel.	No apparent damage.	No apparent damage.	No apparent damage.
C-8	Top coat gone. Primer apparently intact. Panel has yellow spots and large blisters with red color on edges.	Some gravel damage.	No apparent damage.	No apparent damage.

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station.
C-10	Coating completely gone on one panel. Practically gone on the other one. Deep charring in the resinous grain.	Surface covered with fine to large blisters. Considerable flaking and charring.	Small to large red blisters. A number of large blisters have flaked off leaving the wood exposed. The exposed wood has a red deposit on it.	A few red spots on the resinous grain. Probably incipient blisters.
C-11	Coating completely gone on one panel and partially left on other. Deep char in resinous grain on both panels.	Excessive charring and blistering. Some flaking of blisters. Pitting of top coat.	Charring in the resinous portion with very fine blisters over the surface.	Covered with fine blisters on the resinous grain.
C-12	Surface covered with fine blisters and pitting. Some large blisters on one end exposing the panel.	Some gravel damage.	No apparent damage.	No apparent damage.

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
C-13	Surface charred and alligatoring. Coating gone in spots leaving a black surface deposit.	Considerable blistering and flaking of top coat. Blisters red in color	No apparent damage	No apparent damage
C-15	Coating gone. Deep char in resinous grain. Less char in nonresinous grain.	Excessive surface charring especially in the resinous grain. Resinous grain red in color.	Fine to large blisters over the surface of the panel. Some blisters have flaked off exposing the panel to charring.	Covered with blisters on the resinous grain.
C-16	Surface shows scorching, checking, and alligatoring. Contains very fine blisters.	One panel shows a few small blisters along one edge. Other panel shows small to large blisters along one edge and small blisters along the other edge.	No apparent damage	No apparent damage

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
C-17	One panel surface blackened in spots and covered with a coating of grit and dirt. The other panel is blistered, charred, and covered with grit and dirt.	Some blistering and smoke smudging	No apparent damage	No apparent damage
C-18	Surface covered with black char.	No apparent damage	No apparent damage	No apparent damage
C-20	Coating melted and fused onto the panels. Alligatoring and embedding of dust on the edges.	A small amount of gravel damage and smoke smudging.	No apparent damage	No apparent damage
P-1	Some gravel damage. Slight bow in panel. Back up panel charred.	Back up panel scorched. Some embedded dirt.	No apparent damage	No apparent damage
P-2	Some gravel damage. Slight bow in panel. Back up panel charred.	Back up panel scorched.	No apparent damage	No apparent damage

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
P-3	No apparent damage. Spotted scorching of back up panel.	No apparent damage. Back up panel not scorched.	No apparent damage	No apparent damage
P-4	Some scorching and blackening. Some bowing of panel. No scorching of back up panel.	No apparent damage. Back up panel not scorched.	No apparent damage	No apparent damage
P-5	Scorching and charring of part of panel. Scorching of back up panel. Some bowing of panel.	No apparent damage. Incipient scorching in the nonresinous grain of the back up panel.	No apparent damage	No apparent damage
P-6	Completely gone. Back up panel scorched.	Sample was warped and shrunk. Contains embedded dirt. Back up panel scorched.	No apparent damage	No apparent damage
P-7	Completely gone. Back up panel scorched.	Warped and stretched. Milky in color. Back up panel scorched.	Completely gone	Torn, probably due to blast damage

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
P-8	Completely gone. Slight scorching.	Completely gone. Some scorching on back up panel.	Completely gone.	Completely gone.
P-9	Completely gone. Back up panel charred.	Completely gone. Back up panel scorched.	Completely gone.	Warped and wrinkled. Partially pulled away from frame.
P-10	Completely gone. Back up panel char-red.	Melted into near the end. Back up panel scorched.	No apparent damage.	No apparent damage.
P-11	Completely gone. Back up panel charred.	No apparent damage. Back up panel scorched.	No apparent damage.	No apperent damage.
P-12	Completely gone. Back up panel charred.	No apparent damage. Back up panel scorched.	No apparent damage.	No apparent damage.
P-13	Coating gone. Glass fiber left. Back up panel charred.	Scorched but still present. Back up panel scorched.	No apparent damage.	No apparent damage.
P-14	Completely gone. Back up panel charred.	Completely gone. Back up panel scorched	No apparent damage.	No apparent damage.

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
P-15	Completely gone. Back up panel charred.	Completely gone. Back up panel scorched.	Completely gone.	Slightly melted and frayed.
P-16	Completely gone. Back up panel charred.	Melted through at one end and frizzled up. Back up panel scorched.	No apparent damage.	No apparent damage.
CF-1	Surface charred. Contains embedded dirt. Back up panel charred in between strips.	Scorched. Darkened in color. Back up panel between strips scorched.	No apparent damage	No apparent damage
CF-2	Surface charred. Contains embedded dirt. Back up panel charred in between strips.	Scorched and darkened in color. Some embedded dirt and gravel. Back up panel scorched.	No apparent damage	No apparent damage.
CF-3	Surface charred. Contains embedded dirt. Back up panel charred between strips.	Blackened in color. No embedded dirt. Back up panel scorched.	No apparent damage	No apperent damage

TABLE C-5 (Cont.)

Material	5000 ft Station	7000 ft Station	9000 ft Station	12000 ft Station
CF-4	Completely gone.	Blackened in color. No embedded dirt. Back up panel scorched.	No apparent damage	No apparent damage
CF-5	Surface char. Back up panel charred between strips.	Smoke smudging. No other apparent damage.	No apparent damage	No apparent damage
CF-6	Surface char. Some embedded dirt.	Slight char. No embedded dirt.	No apparent damage	No apparent damage
CF-7	Panel showed surface char and embedded dirt and gravel	Melted surface. Some surface char. Some embedded dirt.	Some surface melting gravel and dirt embedded in surface.	No apparent damage
CF-8	Completely gone.	Completely gone. Back up panel charred.	No apparent damage.	No apparent damage

Table C-6

Effect of Thermal Flux on Resistance to Salt Spray

SHOT	TEST	C1	C2	C5	C6	C7	C8	C12	C13	C16	C20
D2 17.5 Cal	Flexibility	12.1	<3.92	5.97	9.53	9.53	10.5	<3.92	<3.92	5.0	4.76
	Abrasion	316.1	281.0	443.0	138.8	378.0	84.0	108.5	212.8	208.0	96.6
	Shear Hardness	96.5	105.0	102.0	88.2	85.2	91.2	80.0	101.5	101.5	92.0
D4 5 Cal	Flexibility	8.0	<3.92	<3.92	>28.6	8.0	5.26	<3.92	<3.92	6.78	12.10
	Abrasion	153.6	165.9	78.5	116.5	111.8	97.8	78.8	81.0	75.2	25.6
	Shear Hardness	71.2	37.5	49.5	85.2	62.0	50.0	78.8	59.2	59.5	*
D5 3.2 Cal	Flexibility	<3.92	<3.92	8.6	>28.6	4.8	<3.92	<3.92	<3.92	5.97	12.1
	Abrasion	122.0	197.0	125.4	100.4	101.2	108.6	86.5	63.5	89.2	83.0
	Shear Hardness	49.5	56.8	37.2	66.2	53.0	51.8	58.0	50.5	55.5	*
D7 1.6 Cal	Flexibility	12.1	<3.92	5.97	<3.92	6.35	5.55	<3.92	<3.92	<3.92	8.6
	Abrasion	93.4	99.5	87.2	94.7	102.8	87.4	37.0	88.3	69.6	68.4
	Shear Hardness	51.2	46.2	50.5	58.0	55.0	54.2	54.8	58.2	60.5	*
D5 18.5 Cal	Flexibility	5.26	<3.92	<3.92	16.0	<3.92	6.35	7.27	<3.92	3.6	8.0
	Abrasion	107.5	453.0	130.5	164.0	410.0	234.0	235.0	194.0	71.0	53.5
	Shear Hardness	66.8	112.5	68.2	123.2	61.2	95.0	101.5	81.2	80.2	107.2
D7 9.8 Cal	Flexibility	5.97	<3.92	5.26	>28.6	9.53	<3.92	<3.92	<3.92	7.27	>28.6
	Abrasion	136.4	101.0	98.7	43.0	63.6	89.0	50.5	82.8	76.4	66.5
	Shear Hardness	53.0	46.5	49.5	69.0	51.2	55.0	67.8	83.2	74.5	*
D9 5.7 Cal	Flexibility	5.0	<3.92	5.97	>28.6	5.55	4.76	<3.92	<3.92	[illegible]	10.5
	Abrasion	140.8	126.1	136.5	119.7	119.0	96.8	47.8	65.1	54.8	46.4
	Shear Hardness	49.5	46.2	42.8	58.8	51.0	53.0	69.2	58.2	55.0	*
D12 3.3 Cal	Flexibility	<3.92	<3.92	5.26	>28.6	9.53	8.0	<3.92	<3.92	<3.92	12.1
	Abrasion	84.6	92.5	131.3	99.5	111.0	110.5	69.6	87.7	51.6	83.5
	Shear Hardness	53.8	42.0	47.2	62.8	51.5	52.5	64.8	61.5	46.2	*
0 unexposed	Flexibility	12.1	<3.92	12.1	>28.6	12.1	<3.92	<3.92	<3.92	5.97	12.1
	Abrasion	101.0	84.5	132.7	72.4	75.6	100.0	71.7	49.8	58.0	84.4
	Shear Hardness	49.2	43.8	44.5	54.0	50.2	54.2	62.8	55.2	56.0	*

Flexibility: % elongation

Abrasion: film loss (10^{-4} Ml)

Shear Hardness: 10^{-3} in.

* Barely Discernible

Table C-7

Effect of Thermal Flux on Resistance to Accelerated Weathering

SHOT	TEST	C1	C2	C5	C6	C7	C8	C12	C13	C16	C20
B2 17.5 Cal	Flexibility	12.1	5.97	9.53	>28.6	<3.92	9.53	<3.92	<3.92	5.55	4.76
	Abrasion	250.0	361.0	338.0	174.2	220.8	229.0	88.4	218.0	175.5	87.9
	Shear Hardness	55.8	69.5	69.5	62.8	80.2	78.0	72.5	66.8	86.5	90.0
B4 5 Cal	Flexibility	10.5	<3.92	5.97	>28.6	5.26	<3.92	<3.92	<3.92	<3.92	<3.92
	Abrasion	142.0	145.0	108.1	102.6	112.6	108.9	108.3	64.9	66.0	66.3
	Shear Hardness	47.2	43.5	43.8	46.2	46.5	43.8	59.2	69.8	52.5	*
B5 3.2 Cal	Flexibility	<3.92	<3.92	8.0	>28.6	12.1	<3.92	<3.92	<3.92	<3.92	<3.92
	Abrasion	84.0	134.1	106.8	111.2	112.0	110.0	77.9	71.4	80.3	91.2
	Shear Hardness	35.2	39.5	43.8	55.0	47.8	50.8	59.2	47.5	47.8	*
B7 1.6 Cal	Flexibility	9.53	<3.92	9.53	>28.6	<3.92	<3.92	<3.92	<3.92	<3.92	<3.92
	Abrasion	74.5	105.4	92.6	108.0	94.4	90.0	48.5	47.8	46.6	106.9
	Shear Hardness	43.8	45.8	51.0	39.0	51.5	48.2	65.5	55.8	48.2	*
D5 18.5 Cal	Flexibility	<3.92	<3.92	<3.92	8.0	<3.92	<3.92	<3.92	<3.92	<3.92	<3.92
	Abrasion	109.0	254.0	252.0	251.5	254.0	305.0	97.5	95.5	94.6	85.8
	Shear Hardness	58.0	58.5	58.2	62.2	59.8	82.0	75.8	89.2	79.2	78.0
D7 9.8 Cal	Flexibility	12.1	<3.92	5.97	<3.92	<3.92	<3.92	<3.92	<3.92	5.26	<3.92
	Abrasion	56.2	83.5	81.0	81.5	82.7	107.7	62.4	67.1	61.0	67.8
	Shear Hardness	32.2	29.0	43.8	55.2	43.8	40.5	47.5	56.5	68.0	*
D9 5.7 Cal	Flexibility	10.5	<3.92	<3.92	>28.6	<3.92	<3.92	<3.92	<3.92	5.26	<3.92
	Abrasion	117.0	100.0	83.2	111.5	95.1	99.3	55.7	58.4	67.5	78.5
	Shear Hardness	44.5	44.5	46.0	54.0	41.8	42.2	48.2	38.5	40.2	*
D12 3.3 Cal	Flexibility	12.1	<3.92	<3.92	>28.6	<3.92	<3.92	<3.92	<3.92	<3.92	<3.92
	Abrasion	84.0	79.5	72.0	66.0	72.5	76.2	52.0	57.1	41.4	60.3
	Shear Hardness	45.8	34.8	42.0	41.5	51.0	47.0	60.0	49.0	56.5	68.2
0 un-exposed	Flexibility	9.53	<3.92	5.97	>28.6	5.26	<3.92	<3.92	<3.92	<3.92	<3.92
	Abrasion	88.8	86.4	86.4	79.2	85.5	83.8	52.7	44.7	51.5	83.8
	Shear Hardness	41.0	31.5	50.0	51.0	51.2	48.2	62.8	49.0	51.8	*

Flexibility: % elongation

Abrasion: film loss (10^{-4} ml.)

Shear Hardness 10^{-3} in.

* Barely Discernible

Table C-8

Effect of Thermal Flux on Resistance to High Humidity

SHOT	TEST	C1	C2	C5	C6	C7	C8	C12	C13	C16	C20
B2 17.5 Cal	Flexibility	12.1	<3.92	10.5	>28.6	<3.92	12.1	<3.92	4.76	8.0	8.0
	Abrasion	289.0	466.0	362.0	182.0	394.0	205.0	100.0	176.0	167.4	133.6
	Shear Hardness	84.5	110.8	106.5	61.0	82.8	70.8	61.0	83.8	91.0	90.0
B4 5 Cal	Flexibility	12.1	<3.92	5.97	>28.6	<3.92	<3.92	<3.92	<3.92	<3.92	10.5
	Abrasion	138.9	253.5	171.0	101.1	96.7	90.6	60.5	82.9	51.9	70.4
	Shear Hardness	43.5	32.5	59.0	51.8	46.0	39.0	58.8	87.5	65.5	*
B5 3.6 Cal	Flexibility	9.53	<3.92	6.78	>28.6	<3.92	<3.92	<3.92	<3.92	<3.92	12.1
	Abrasion	158.0	231.0	173.0	135.0	138.0	169.2	40.7	65.0	66.0	89.8
	Shear Hardness	30.8	113.0	32.0	43.2	40.0	43.8	63.2	55.2	51.5	*
B7 1.6 Cal	Flexibility	<3.92	<3.92	6.78	<3.92	<3.92	<3.92	<3.92	<3.92	<3.92	16.0
	Abrasion	150.5	114.3	116.0	107.0	84.8	78.1	46.0	41.2	50.6	61.3
	Shear Hardness	30.8	31.8	32.0	63.2	38.8	37.0	51.8	54.0	55.0	*
D3 18.5 Cal	Flexibility	6.78	<3.92	<3.92	>28.6	<3.92	<3.92	<3.92	<3.92	4.76	9.53
	Abrasion	316.0	300.0	416.0	176.7	333.0	343.0	68.0	103.2	125.9	105.7
	Shear Hardness	84.0	72.2	72.2	64.5	69.5	74.5	72.5	88.0	75.2	91.2
D7 9.8 Cal	Flexibility	6.78	<3.92	4.76	>28.6	<3.92	<3.92	<3.92	<3.92	<3.92	28.6
	Abrasion	162.5	173.0	133.8	113.5	85.4	81.4	47.8	72.2	63.5	82.9
	Shear Hardness	37.0	89.8	31.2	53.8	36.0	42.8	52.8	77.2	76.2	*
D9 5.7 Cal	Flexibility	4.76	<3.92	<3.92	>28.6	<3.92	<3.92	<3.92	<3.92	<3.92	16.0
	Abrasion	127.0	191.0	120.8	121.5	95.3	87.4	42.6	51.5	58.7	72.9
	Shear Hardness	30.2	34.0	32.8	43.8	30.0	34.2	52.8	51.5	57.2	*
D12 3.3 Cal	Flexibility	12.1	<3.92	5.97	>28.6	<3.92	<3.92	<3.92	<3.92	5.97	>28.6
	Abrasion	101.0	116.0	101.4	82.9	82.3	84.9	52.4	80.0	62.8	99.3
	Shear Hardness	27.2	29.5	37.8	42.2	40.8	33.8	62.0	55.8	52.0	*
0 un-exposed	Flexibility	12.1	<3.92	5.26	>28.6	<3.92	<3.92	<3.92	<3.92	<3.92	12.1
	Abrasion	192.8	206.0	192.0	203.6	126.3	123.0	87.9	54.9	59.6	100.0
	Shear Hardness	34.8	27.0	40.2	63.5	39.8	44.2	66.2	61.0	51.8	*

Flexibility: % elongation

Abrasion: film loss (10^{-4} ml)

Shear Hardness 10^{-3} in.

* Barely Discernible

TABLE C-9

Effect of High Humidity on Painted Panels Exposed to a Thermal Energy of 85 Cal/Cm^2

System	Surface Condition
Unexposed Bare Panel	Entire surface covered uniformly with medium to heavy rusting.
C1	Light blue in color. Coating gone. Light rust spots covering about 40% of panel.
C5	Blue in color. Coating gone. Light rusting over about 20% of panel.
C6	Burned appearance to metal. Coating gone. Rust on several drip streaks.
C7	Mettalic blue color. Coating gone. Light rusting over entire surface.
C12	About 10% of coating still intact. Light rusting on bare spots. Rust on drip streaks.
C13	About 5% of coating still intact. Only slight signs of white corrosion. Considerable abrasion damage.
C16	Light rusting on blued portions. Coating gone. Medium rusting on unburned metal.
C20	Coating gone. Brownish-gray color surface. Light rusting over entire surface.

TABLE C-10

Effect of Thermal Flux on Overall Flexibility
(% Elongation)

Critical Energy Level Cal/Cm^2	Coating Systems									
	C1	C2	C5	C6	C7	C8	C12	C13	C16	C20
17.5	12.1	4.6	8.7	22.2	5.8	10.7	3.9	4.2	6.2	5.8
18.5	5.3	3.9	3.9	14.2	3.9	4.4	5.0	3.9	5.8	7.2
9.6	5.3	3.9	5.3	20.4	5.8	3.9	3.9	3.9	5.5	20.4
5.6	10.2	3.9	5.0	28.6	5.7	4.4	3.9	3.9	4.9	8.8
5.0	6.8	3.9	4.6	28.6	4.5	4.2	3.9	3.9	5.5	10.1
3.2	5.1	3.9	7.8	28.6	6.9	3.9	3.9	3.9	4.6	9.4
3.7	9.3	3.9	5.1	28.6	5.8	5.3	3.9	3.9	4.6	14.9
1.7	8.5	3.9	7.4	12.1	4.7	4.5	3.9	3.9	3.9	9.5
0	11.2	3.9	7.8	28.6	7.1	3.9	3.9	3.9	4.6	9.3

TABLE C-11

Effect of Thermal Flux on Abrasion Over-all Resistance
(Film loss in 10^{-4}Ml)

Critical Energy Level	Coating Systems									
Cal/Cm^2	C1	C2	C5	C6	C7	C8	C12	C13	C16	C20
17.5	217	369	381	165	331	173	99	202	184	106
18.5	178	336	266	198	332	294	134	131	97	82
9.6	132	120	104	80	77	93	54	74	67	73
5.6	132	188	119	107	107	99	83	76	64	54
5.2	128	139	110	118	103	94	49	58	61	66
3.2	121	187	136	115	117	129	68	67	78	88
3.7	90	96	101	83	88	91	58	68	52	81
1.7	106	106	99	103	94	85	44	59	56	79
0	128	126	137	119	96	103	71	50	57	89

TABLE C-12

Effect of Thermal Flux on Shear Over-all Hardness
(Width of Scratch in 10^{-3} in.)

Critical Energy Level Cal/Cm^2	C1	C2	C5	C6	C7	C8	C12	C13	C16	C20
	Coating Systems									
17.5	78.9	95.1	92.7	70.7	82.8	80.0	71.2	84.0	93.0	90.7
18.5	69.6	81.1	66.2	83.3	63.5	33.8	83.2	86.2	78.2	Barely discernible due to white color
9.6	40.8	55.1	41.5	59.3	43.7	46.1	56.0	72.3	72.9	
5.6	54.0	37.8	50.8	60.4	51.5	44.2	65.9	72.2	59.2	
5.0	41.4	41.6	40.5	52.0	40.9	43.2	56.8	49.4	50.8	
3.2	38.5	69.8	37.7	54.8	46.9	48.8	60.2	51.1	51.6	
3.7	42.2	35.4	42.3	48.8	47.8	44.4	62.2	55.4	51.6	
1.7	41.9	41.2	44.5	53.4	48.4	46.5	64.0	56.0	54.6	
0	41.7	34.1	44.9	56.8	47.1	48.9	63.9	55.1	53.2	

TABLE C-13

Effect of Thermal Exposure on the Properties of Fire Retardant Paint

Thermal Exposure Cal/Cm^2	House Paint (TT-P-40)		Fire Retardant Paint (VV#20)	
	Weight Loss Grams	Char Volume Cubic Inch	Weight Loss Grams	Char Volume Cubic Inch
Unexposed	14.8	5.84	11.7	5.45
1.7	10.8	3.98	9.4	3.92
3.7	12.0	4.81	10.8	4.39
3.2	12.4	3.95	9.4	3.88
5.0	12.6	4.67	10.1	3.44
5.6	11.7	5.0	9.2	3.05
9.6	11.9	5.0	9.0	2.83
13.5	11.2	7.29	16.7	6.91
17.5	12.5	5.01	14.3	5.79
85	116.0	Burned up completely	49.83	12.45

TABLE C-14

Effect of Thermal Flux on Rigid Plastics

Material	Thermal Energy (Cal/cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Methyl Methacrylate									
Flexual Strength 1000 psi	14.1	14.3	13.1	15.1	16.3	16.7	15.6	13.3	14.3
Mod of Elasticity 1000 psi	397	322	410	325	341	475	510	460	294
Specific Gravity 60/60 F	1.17	1.18	1.18	1.18	1.18	1.18	1.19	1.18	1.17
Rockwell Hardness m scale	97.5	97.0	96.0	96.0	97.0	83.0	98.0	97.0	95.0
Light Transmittance %	92.2	91.9*	92.6	92.7	92.5	92.5	89.1	51.6	47.2
Cellulose Acetate									
Flexual Strength 1000 psi	9.2	9.3	8.1	9.6	10.2	9.6	10.3	8.5	*10.3A 9.6B
Mod of Elasticity 1000 psi	206	164	240	384	177	176	193	245	259A 260B
Specific Gravity 60/60 F	1.30	1.31	1.30	1.31	1.31	1.31	1.30	1.30	1.31A 1.31B
Rockwell Hardness m scale	83.5	82.0	79.0	81.0	79.0	81.0	79.0	81.8	78.0A 76.0B

TABLE C-14 (Cont.)

Effect of Thermal Flux on Rigid Plastics

Material	Thermal Energy (Cal/Cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Light Transmittance %	89.0	89.5	88.9	88.7*	88.6*	89.5	87.8	43.4	60.1A 17.7B
Polyester Resin Reinforced with Glass Mat									
Flexual Strength 1000 psi	28.5	23.1	24.6*	20.3*	2.1A 2.6B	30.3	29.2	29.2	23.2A 22.6B
Mod. of Elasticity 1000 psi	1,375	1,230	1,130*	1,130	1,170	990	1230	1,290	1070A 1020B
Specific Gravity 60/60 F	1.44	1.35	1.40	1.35	1.38A 1.36B	1.42	1.36	1.41	1.38
Rockwell Hardness m scale	111	111.2	109.1	106.3	105.8A 106.5B	109.6	111.9	111	109.3
Light Transmittance %	32.1	32.1	26.7	25.6	25.6A 22.4B	34.5	25.9	19.7	31.2A 10.3B*
Inert Materials %	28.6*	24.6*	33.2*	29.2*	28.4*	28.6*	29.6*	35.2*	30.8*
Phenol-Formaldehyde Resin Reinforced with Asbestos									
Flexual Strength 1000 psi	12.6	14.9	11.8	16.4	12.9	12.1	13.1	12.6	14.4

TABLE C-14 (Cont.)

Material	Thermal Energy (Cal/Cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Mod of Elasticity 1000 psi	1,375	1,085	1,342	1,110	1,005	1,830	1,460	1,270	1,375
Specific Gravity 60/60 F	1.59	1.61	1.63	1.63	1.62	1.59	1.58	1.59	1.61
Rockwell Hardness m scale	110.2	99.2	94.9	98.4	98	107.5	110.4	102.5	93
Inert Material %	37	39.3	39.7	39.2	39.6	38.2	37.2	37.6	41.4
Polyvinyl Chloride									
Flexual Strength 1000 psi	15.4	16.4	15.6	16.2	17.1	17.3	15.6	15.7A 13.6B	16.7A 16 B
Mod. of Elasticity 1000 psi	475	410	407	474	484	406	404	536	456 A 477B
Specific Gravity 60/60 F	1.37	1.36	1.36	1.36	1.36	1.36	1.28	1.36A 1.35B	1.35A 1.34B
Rockwell Hardness m scale	84.1	83.1	84.0	84.0	84.0	82.0	85.0	81.9A 79.0B	79.0A 92.0B
Light Transmittance %	75.5	75.1	75.5	75.4	75.2	75.6	75.6	26.4A 17.6B	61.2A 34.8B

6(B) refers to 6 calorie level in BAKER SHOT. 6(D) refers to 6 calorie level in DOG SHOT.
A in the table refers to section of sample with least visual damage.
B in the table refers to section of sample with most visual damage.
* indicates an average of less than 5 and more than 2 tests.

TABLE C-15

Effect of Thermal Flux on Plastic Films

Material	Thermal Energy (Cal/Cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Polyethylene									
Breaking Strength psi	1570	1690	1340	1480	1450	1690	1640	-	-
Elongation, %	700+	700+	700+	700+	700+	700+	700+	-	-
Specific Gravity 60/60 F	0.87	0.92	0.83	0.84	0.96	0.84	0.99	-	-
Teflon									
Breaking Strength psi	1540	1460	1350	1460	1340	-	1660	-	-
Elongation, %	215	215	215	191	185	-	96	-	-
Specific Gravity 60/60 F	1.93	1.84	1.78	1.78	1.77	-	1.74	-	-
Saran									
Breaking Strength psi	9900	8300	10,100	10,500	5330	-	4600	-	-
Elongation, %	59	36.7	63.4	22	5	-	15	-	-
Specific Gravity 60/60 F	1.69	3.65	2.6	2.6	-	-	-	-	-

Film Thicknesses: Polyethylene 0.0042 in.
Teflon 0.0026 in.
Saran 0.0021 in.

6(B) refers to 6 calories on BAKER Shot.
6(D) refers to 6 calories on DOG Shot.

TABLE C-16

Effect of Thermal Flux on Plastic and Cotton Fibers

Material	Thermal Energy (Cal/Cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Dynel									
Straight Strand Breaking Strength lbs	35.9	36.6	36.5	34.2	36.5	36.0	15	-	-
Ultimate Elongation %	66	40	53	53	53	48	30	-	-
Knotted Strand Breaking Strength lbs	20	17	19	19.7	19.7	21.8	18	-	-
Ultimate Elongation %	37	31	33	36	37	40	46	-	-
Orlon									
Straight Strand Breaking Strength lbs	50.3	48.1	47.1	48.8	45.6	50.7	46.9	-	-
Ultimate Elongation %	-	37	41	34	44	33	45	-	-
Knotted Strand Breaking Strength lbs	24.6	22.4	24.2	22.7	22.5	24.4	23.1	-	-
Ultimate Elongation %	34	20	22	20	21	23	22	-	-

TABLE C-16 (Cont.)

Material	Thermal Energy (Cal/Cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Cotton									
Straight Strand									
Breaking Strength lbs	29.3	29.9	27.4	31.2	30.4	27.7	29.7	-	-
Ultimate Elongation %	18	11.7	11.7	11.7	12.8	12.6	14	-	-
Knotted Strand									
Breaking Strength lbs	24.9	20.5	21.5	23.2	22.7	21.8	21.4	-	-
Ultimate Elongation %	20.4	14.9	17.7	17.8	16	17	17	-	-
Vinyl Covered Fiberglass									
Straight Strand									
Breaking Strength lbs	37.1	41.7	-	37	38.7	39.5	42.7	37	38.3
Ultimate Elongation %	7	35	-	-	-	-	-	-	-
Knotted Strand									
Breaking Strength lbs.	22	18.2	20.2	18.7	21.7	18.7	21.2	18.7	16
Ultimate Elongation %	28	20	15	25	22	20	25	25	17

TABLE C-16 (Cont.)

Material	Thermal Energy (Cal/Cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Nylon Untreated									
Breaking Strength lbs	49	49	55.4	49.4	43.2	51.2	18.7	-	-
Straight Strand Ultimate Elongation %	-	-	-	-	-	-	50	-	-
Knotted Strand Breaking Strength lbs	32.7	31.5	28.7	28.7	29.8	27.7	15.4	-	-
Ultimate Elongation %	75	-	68	69.7	68	60	45	-	-
Saran									
Straight Strand Breaking Strength lbs	42.2	35.5	12	7.7	-	-	-	-	-
Ultimate Elongation %	31	18	-	-	-	-	-	-	-
Knotted Strand Breaking Strength lbs	27.2	29	8.2	7.7	-	-	-	-	-
Ultimate Elongation %	21.3	19	10	-	-	-	-	-	-

TABLE C-16 (Cont.)

Material	Thermal Energy (Cal/Cm^2)								
	Unexposed	1.6	3.7	3.2	5	5.6	9.6	18.5	17.5
Nylon FM 3606									
Straight Strand									
Breaking Strength lbs	42.3	32.4	40.4	44	44.5	44	36.5	-	-
Ultimate Elongation %	-	-	-	-	-	-	95	-	-
Knotted Strand									
Breaking Strength lbs	31.3	27.6	26.3	26.6	27.8	25.2	27	-	-
Ultimate Elongation %	-	60.8	54	58	55	47	77	-	-

TABLE C-17

Effect of Thermal Flux on the Breaking Strength of Rubber Coated Fabrics

Material	Thermal Flux (Cal/Cm^2)								
	Unexposed	1.6	3.6	3.2	5B	5.6	9.6	18.5	17.5
Natural	122	131	135	132	135	132	65.5	132	None
Neoprene GN	121	119	110	115	115	114	118	98	83
GR-I	130	131	124	129	129	141	135	123	87
GR-S	122	105	115	123	119	115	117	32	None
GR-A	109	105	119	116	116	121	112	114	None
Vinyl	130	138	136	119	140	135	103	105	78
Uncoated Duck	148	128	132	129	149	132	75	None	None
Neoprene (Lab. Batch)	68	67	65	67	63	48	None	None	None

Breaking strength in lbs/in

TABLE C-18

Effect of Thermal Flux on the Ultimate Elongation of Rubber Coated Fabrics

Material	Thermal Flux (Cal/Cm^2)								
	Unexposed	1.6	3.6	3.2	5	5.6	9.6	18.5	17.5
Natural	11	13	13	12	11	10	4	11	None
Neoprene GN	12	15	13	12	12	14	11	7	7
GR-I	12	13	12.5	11	11	13	12	13	8
GR-S	9	9	10.5	11	11	10	10	9	None
GR-A	12	13	14	14	13	12	11	11	None
Vinyl	12	14	15	14	13	12	8	8	5
Untreated Duck	12	14	13	12	12	14	7	None	None
Neoprene (Lab. Batch)	19	19	18	18	15	15	None	None	None

Ultimate elongation in %

Table C-19

Comparison of Thermal Effects
Laboratory Flux vs. Field Exposure
COATING SYSTEMS

Critical Energy Cal./Cm.^{2}	System C1		System C2	
	Laboratory	Field	Laboratory	Field
1.6	No test	Some smoke Damage on one panel	No test	No apparent damage
3.2	No test	No apparent damage. A few scattered bits of gravel imbedded in the surface	No test	Some of the blisters flaked away exposing panel
3.3	No test	No apparent damage	No test	No apparent damage
3.8	No apparent damage	No apparent change in color of sheen. Some erosion and gravel damage. A few fine blisters	No apparent damage	A few fine blisters. Some surface erosion and gravel damage. Some imbedded dust.
5.2	No apparent damage	No apparent damage	No apparent damage	No apparent damage
9.8	Slight charring of surface	Some gravel damage. Small amount of imbedded dirt	Incipient charring. No blistering	One or two incipient blisters. Some gravel damage and imbedded dirt
13.5	Definite charring of film - film present but no life	Fine blisters. Some pitting of blisters. Some imbedded dirt	Light surface char	Charring on both panels. One panel shows fine blisters and pitting, the other blistering and flaking
17.5	Film charred, life gone out of film	Small blisters evenly over the surface. Blisters broken to show pitting. Some imbedded dirt	Light surface char	Surface coat charred and blistered. Thin undercoat is o.k. Two top coats gone

Critical Energy Cal./Cm.^{2}	System C4		System C5	
	Laboratory	Field	Laboratory	Field
1.6	Scattered blisters	No apparent damage	No test	No apparent damage
3.2	Scattered blisters red in color	Scattered blisters small to large	No test	No apparent damage
3.3	Scattered blisters red in color - some charred	Small to large. Reddish blisters in the resinous grain	No test	No apparent damage
3.8	Top coat pitted, some charring	Small to large blisters in resinous grain. Grain red. Blisters black	No apparent damage	Some surface erosion and an occasional blister. No appreciable amount of imbedded dirt

Table C-19 (cont.)

Comparison of Thermal Effects Laboratory Flux vs. Field Exposure

COATING SYSTEMS

Critical Energy Cal./Cm.^{2}	System C4		System C5	
	Laboratory	Field	Laboratory	Field
5.2	Top coat pitted and charred, undercoat intact	Small to large blisters. Blisters red and black	No apparent damage	No apparent damage
9.8	Top coat gone, undercoat intact	Charring and blistering in the resinous grain	No apparent damage	Some gravel damage. Some imbedded dirt
18.5	Coating gone, browning of wood	Coating gone, resinous grain charred	Some redening. No blisters	Blistering and flaking with exposure of panel. Some charring on the edges
17.5	Coating gone, browning of wood	Coating gone, resinous grain shows deep char	Some redening. No blisters. Some charring	Charring, blistering and flaking
Critical Energy Cal./Cm^2	**System C7**		**System C8**	
	Laboratory	**Field**	**Laboratory**	**Field**
1.6	No test	No apparent damage	No test	No apparent damage
3.2	No test	No apparent damage	No test	No apparent damage
3.3	No test	No apparent damage	No test	No apparent damage
5.8	Some blistering incipient, redening	No visual damage	No apparent damage	No change in color. Some gravel damage. Some imbedded dirt
5.2	No apparent damage	No apparent damage	No apparent damage	No apparent damage
9.8	Hair line cracks with reddning and charring in cracks	No apparent damage	No apparent damage	Some gravel damage
18.5	Blistering, pitting and charring - no metal exposed	Paint completely gone. Large blisters flaked off. Red and green spots on the panel	Small radish spots starting to form. No other apparent damage	Top coat gone. Primer apparently intact. Panel has yellow spots and large blisters
17.5	Severe charring and flaking with panel exposed in spots	Surface coat shows mottled appearance of brown, red, yellow, green, with large flakes	High spots of film show signs of red to black coloring. No other apparent damage	Coating charred, fine pitting to show primer. Some pitting down to metal

Table C-19 (cont.)

Comparison of Thermal Effects
Laboratory Flux vs. Field Exposure

COATING SYSTEMS

Critical Energy Cal./Cm.^{2}	System C10		System C11	
	Laboratory	Field	Laboratory	Field
1.6	No apparent damage	No apparent damage	No apparent damage	No apparent damage
3.2	Fine to medium blisters. Redning of the film	Spotted red spots. Some red blisters	Slight surface char, no blistering	Covered with fine blisters in resinous grain. Scattered blisters in other grain
3.3	Fine to medium blisters, some charring. Redning of the film	A few red spots on the resinous grain	Slight surface char, no blistering	Cove. d with fine blisters on resinous grain
3.8	Top film charred, undercoat intact	Small to large blisters. Resinous grain charred	Coating charred. No charring of wood	Slight fading of color. Resinous grain charred
5.2	Top film charred but intact - covered with blisters	Small to large blisters. No charring of wood	Coating gone. No charring of wood	Fine blisters, charring of resinous wood
9.8	Coating gone. No charring of wood	Surface covered with fine to large blisters. Considerable flaking and charring	Coating gone, very slight surface char	Excessive charring and blistering. Pitting of coating
18.5	Coating gone, slight surface charring	Coating gone, deep charring in resinous grain	Coating gone, surface char of wood	Coating gone, deep char in resinous grain
17.5	Coating gone. Surface charring	Coating gone in spots showing uncharred wood. Resinous grain charred	Coating gone, surface char of wood	Resinous grain charred, other grain not charred

Critical Energy Cal./Cm.^{2}	System C12		System C13	
	Laboratory	Field	Laboratory	Field
1.6	No test	No apparent damage	No test	No apparent damage
3.2	No test	No apparent damage	No test	No apparent damage
3.3	No test	No apparent damage	No test	No apparent damage
3.8	No apparent damage	Some surface erosion. Slight darkening in color. Some imbedded dirt	No apparent damage	Some lightening in color. Considerable blistering and disintegration of top film. Some imbedded dirt

Table C-19 (cont.)

Comparison of Thermal Effects
Laboratory Flux vs. Field Exposure

COATING SYSTEMS

Critical Energy Cal./Cm.^{2}	System C12		System C13	
	Laboratory	Field	Laboratory	Field
5.2	No apparent damage	No apparent damage	No apparent damage	No apparent damage
9.8	Blackening of film surface. No other apparent damage	Some gravel damage	No apparent damage	Considerable blistering and flaking of top coat. Blisters red in color
18.5	Blackening of film surface. No other apparent damage	Surface covered with fine blisters and pitting. Some large blisters ex-posing the panel	Surface charring coating still intact	Surface charred and alligatoring. Coating gone in spots leaving black surface deposits
17.5	No apparent damage (28 cal. shows large black surface de-posits. Film intact)	Charring and blistering of film. Some pitting	Severe blackening of surface with film still intact. No blisters	Charring and alli-gatoring of the surface. One side appears to be burnt off. Some gravel damage

Critical Energy Cal./Cm.^{2}	System C15		System C16	
	Laboratory	Field	Laboratory	Field
1.6	No apparent damage	No apparent damage	No test	No apparent damage
3.2	Some surface char	Covered fine to medium blisters. Some cracking and peeling	No test	No apparent damage
3.5	Some surface char	Covered with blisters on the resinous grain	No test	No apparent damage
3.8	Surface char. No char on wood	Fine to large blisters. Large blisters flaked off showing wood char-ring underneath	No apparent damage	No color change. Few scattered blisters. Some imbedded dirt
5.2	Surface char	Fine to large blisters. Charring under blisters	No apparent damage	No apparent damage
9.8	Coating charred, light charring of wood	Excessive surface charring especially in resinous grain	Very slight darken-ing of film. No other apparent damage	Small to large blisters along edges of panels
18.5	Coating gone, surface charring of wood	Coating gone, deep char in resinous grain, some char in other grain	Slight blackening of surface. Film intact	Scorching, check-ing and alligator-ing. Contains very fine blisters

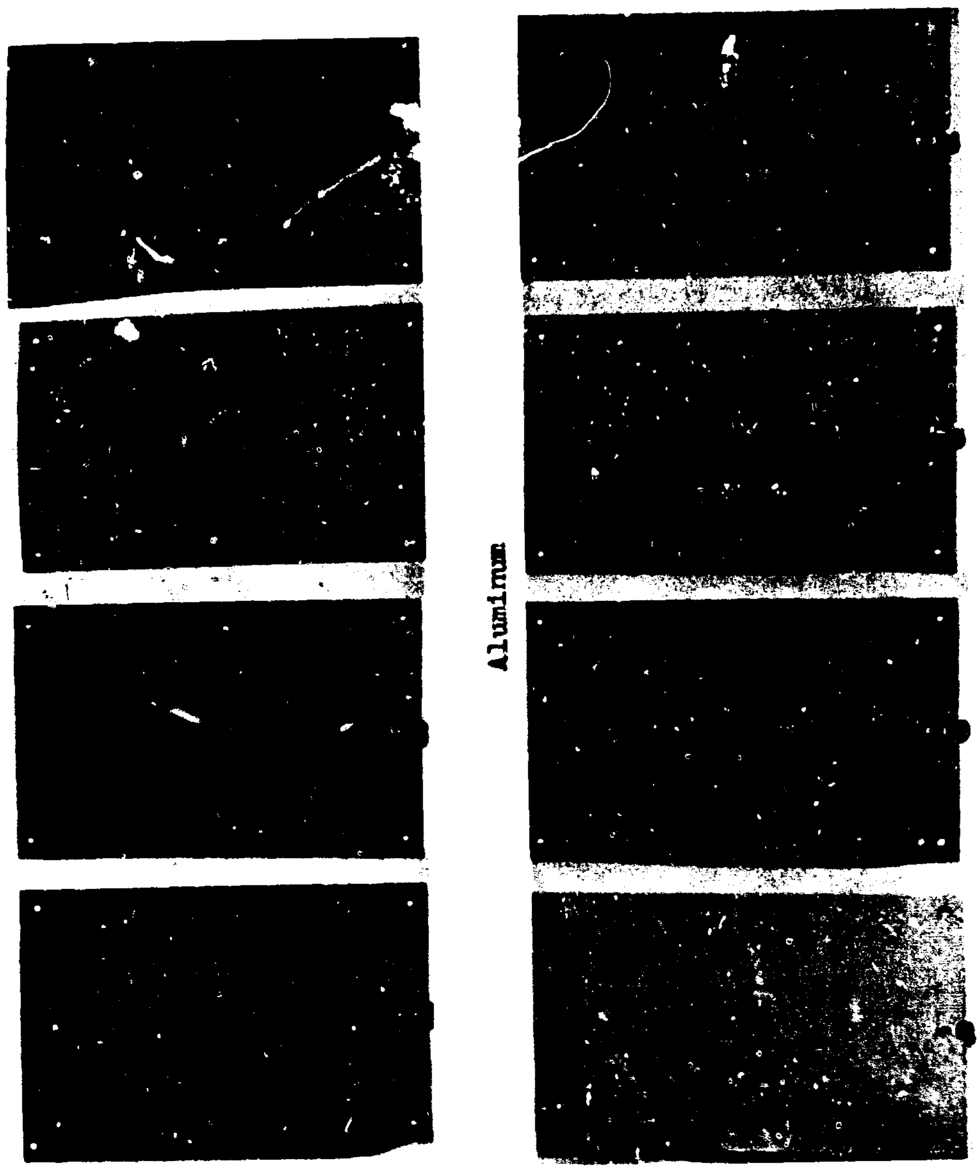
Table C-19 (cont.)

Comparison of Thermal Effects
Laboratory Flux vs. Field Exposure

COATING SYSTEMS

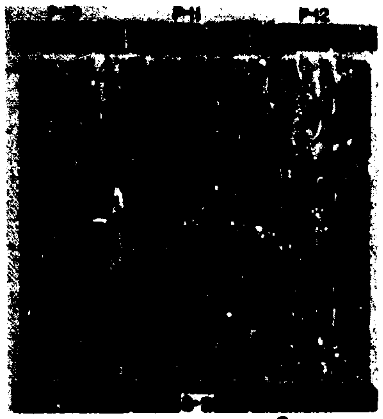
Critical Energy Cal./Cm.^{2}	System C15		System C16	
	Laboratory	Field	Laboratory	Field
17.5	Coating gone, deep charring of wood	Coating gone, wood charred in resinous grain	Slight blackening of surface. Film intact	Surface entirely charred; extreme in spots. Some gravel damage

Critical Energy Cal./Cm^2	System C17		System C18	
	Laboratory	Field	Laboratory	Field
1.6	No test	No apparent damage	No test	No apparent damage
3.2	No test	No apparent damage	No test	No apparent damage
3.3	No test	No apparent damage	No test	No apparent damage
5.8	No apparent damage	No apparent damage	No apparent damage	No apparent damage
5.2	No apparent damage	No apparent damage	No apparent damage	No apparent damage
9.8	Fine blister	Some blistering and smoke smudging	No apparent damage	No apparent damage
18.5	Surface coating charred	One panel charred, other panel blistered and charred	Incipient surface, charring and blistering of coating, no char on wood	Surface char
17.5	Coating gone, some surface char	Coating gone, charring in spots	Coating charred, surface char - wood	Coating charred

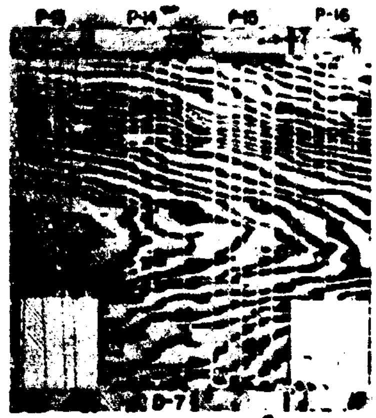


85 cal/cm^2 17.5 cal/cm^2 9.8 cal/cm^2 Unexposed

Fig. C-1 Effect Of Thermal Flux On An Alkyd Lusterless Enamel

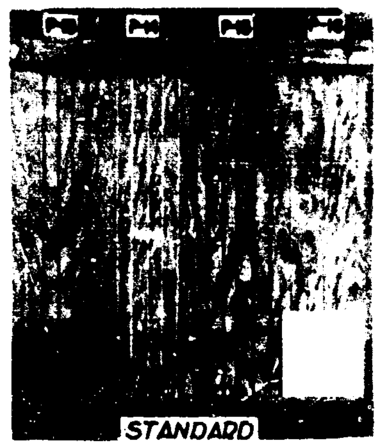


17.5 cal/cm^2

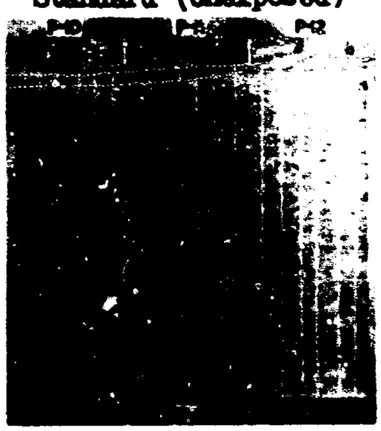


9.8 cal/cm^2

Standard (Unexposed)

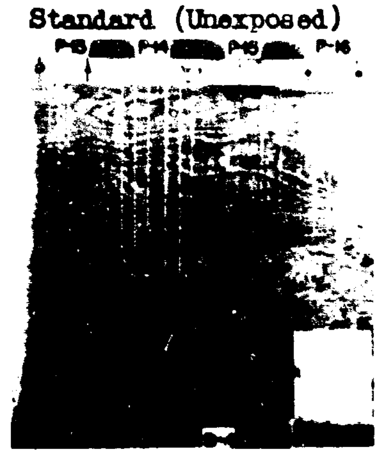


Standard (Unexposed)



5.7 cal/cm^2

P10 Dynel
P11 Orlon
P12 Cotton



5.7 cal/cm^2

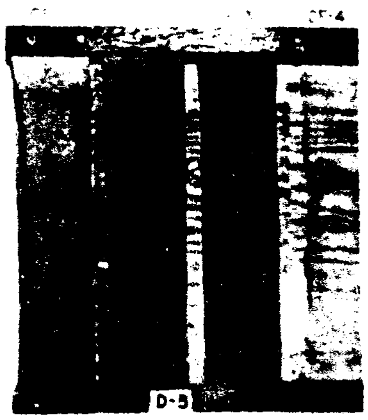
P13 Vinyl Covered Glass
P14 Nylon
P15 Saran
P16 Nylon Monofilm (FM 3606)

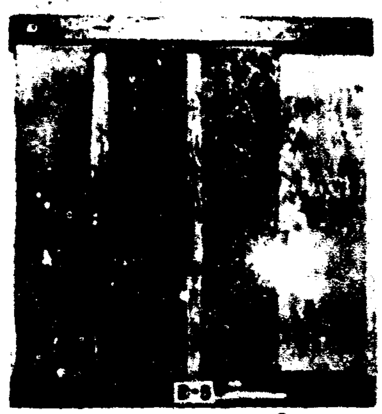
Fig. C-2 Effect of Thermal Flux (cal/cm^2) on Various Fibers

17.5 cal/cm^2 17.5 cal/cm^2

Standard (Unexposed)

Standard (Unexposed)





18.5 cal/cm^2 18.5 cal/cm^2

CF1 GR-S
CF2 GR-I
CF3 Neoprene GN
CF Untreated Duck
CF5 GR-A
CF6 Natural Rubber
CF7 Vinyl Chloride-Acetate Cupol.
CF8 Neoprene (Lab. Batch.)

Fig. C-3 Effect of Thermal Flux (cal/cm^2) on Coated Fabrics

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